California Fish and Game Commission

Meeting Binder

October 9-10, 2019

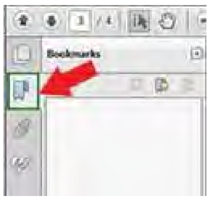
Valley Center

<u>**EASY GUIDE TO USING THE BINDER**</u>

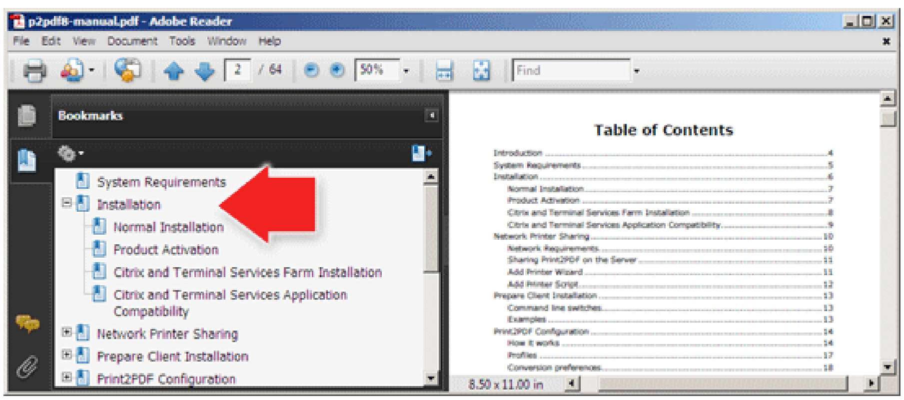
Note: We make every effort to ensure that documents we produce are compliant with Americans with Disabilities Act standards, pursuant to state and federal law; however, some materials included in our meeting binders that are produced by other organizations and members of the public may not be compliant.

1. Download and open the binder document using your Adobe Acrobat program/app.

2. If a bookmark panel does not automatically appear on either the top or left side of the screen, click/tap on the “bookmark symbol” located near the top left-hand corner.



3. To make adjustments to the view, use the Page Display option in the View tab. You should see something like:



4. We suggest leaving open the bookmark panel to help you move efficiently among the staff summaries and numerous supporting documents in the binder. It’s helpful to think of these bookmarks as a table of contents that allows you to go to specific points in the binder without having to scroll through hundreds of pages.

5. You can resize the two panels by placing your cursor in the dark, vertical line  located between the panels and using a long click /tap to move in either direction.

6. You may also adjust the sizing of the documents by adjusting the sizing preferences located on the Page Display icons found in the top toolbar or in the View tab.

7. Upon locating a staff summary for an agenda item, notice that you can obtain more information by clicking/tapping on any item underlined in blue.

8. Return to the staff summary by simply clicking/tapping on the item in the bookmark panel.

9. Do not hesitate to contact staff if you have any questions or would like assistance.

OVERVIEW OF FISH AND GAME COMMISSION BUSINESS MEETINGS

- This year marks the beginning of the 150th year of operation of the California Fish and Game Commission in partnership with the California Department of Fish and Wildlife. Our goal is the preservation of our heritage and conservation of our natural resources through informed decision making. These meetings are vital in achieving that goal. In that spirit, we provide the following information to be as effective and efficient toward that end. Welcome and please let us know if you have any questions.

- We are operating under the Bagley-Keene Open Meeting Act and these proceedings are being recorded and broadcast via https://videobookcase.com/.

- In the unlikely event of an emergency, please note the location of the nearest emergency exits. Additionally, the restrooms are located ______________.

- Items may be heard in any order pursuant to the determination of the Commission President.

- The amount of time for each agenda item may be adjusted based on time available and the number of speakers.

- Speaker cards need to be filled out **legibly** and turned in to the staff **before** we start the agenda item. Please make sure to list the agenda items you wish to speak to on the speaker card.

- We will be calling the names of several speakers at a time so please line up behind the speakers' podium when your name is called. If you are not in the room when your name is called you may forfeit your opportunity to speak on the item.

- When you speak, please state your name and any affiliation. Please be respectful. Disruptions from the audience will not be tolerated. Time is precious so please be concise.

- To receive meeting agendas and regulatory notices about those subjects of interest to you, please visit the Commission's website, www.fgc.ca.gov, and sign up for our electronic mailing lists.

- All petitions for regulation change must be submitted in writing on the authorized petition form, FGC 1, Petition to the California Fish and Game Commission for Regulation Change, available at https://fgc.ca.gov/Regulations/Petition-for-Regulation-Change.

- **Reminder!** Please silence your mobile devices and computers to avoid interruptions.

- **Warning**! The use of a laser pointer by someone other than a speaker doing a presentation may result in arrest.

INTRODUCTIONS FOR FISH AND GAME COMMISSION MEETINGS

Fish and Game Commission

Eric Sklar	President (Saint Helena)
Jacque Hostler-Carmesin	Vice President (McKinleyville)
Russell Burns	Member (Napa)
Peter Silva	Member (Jamul)
Samantha Murray	Member (Del Mar)

Commission Staff

Melissa Miller-Henson	Executive Director
Susan Ashcraft	Acting Deputy Executive Director
Mike Yaun	Legal Counsel
Elizabeth Pope	Acting Marine Advisor
Ari Cornman	Wildlife Advisor
Craig Castleton	Analyst
Sergey Kinchak	Analyst

California Department of Fish and Wildlife

Chuck Bonham	Director
Wendy Bogdan	General Counsel
David Bess	Deputy Director and Chief, Law Enforcement Division
Stafford Lehr	Deputy Director, Wildlife and Fisheries Division
Clark Blanchard	Assistant Deputy Director, Office of Communications, Education and Outreach
Kari Lewis	Chief, Wildlife Branch
Kevin Shaffer	Chief, Fisheries Branch
Craig Shuman	Manager, Marine Region

I would also like to acknowledge special guests who are present:
(i.e., elected officials, including tribal chairpersons, and other special guests)

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STATE OF CALIFORNIA
Gavin Newsom, Governor

Fish and Game Commission

Wildlife Heritage and Conservation
Since 1870

Melissa Miller-Henson
Executive Director
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Sacramento, CA 94244-2090
(916) 653-4899
fgc@fgc.ca.gov

www.fgc.ca.gov

MEETING AGENDA
October 9-10, 2019

Rincon Government Center
One Government Center Lane, Valley Center, CA 92082

The meeting will be live streamed; visit www.fgc.ca.gov the day of the meeting.

NOTE: See important meeting deadlines and procedures at the end of the agenda. Unless otherwise indicated, the California Department of Fish and Wildlife is identified as Department.

Invitation: The Commission invites members of the public to join commissioners and staff for one or more field trips that will take place following the meeting recess on Wednesday; details will be released before the Commission meeting. Members of the public are welcome but must provide their own transportation.

DAY 1 – OCTOBER 9, 2019; 9:00 AM

Call to order/roll call to establish quorum

1. **Consider approving agenda and order of items**

2. **General public comment for items not on agenda**
   Receive public comment regarding topics within the Commission's authority that are not included on the agenda.
   Note: The Commission **may not** discuss or take action on any matter raised during this item, except to decide whether to place the matter on the agenda of a future meeting (sections 11125 and 11125.7(a), Government Code).

CONSENT ITEMS

3. **Foothill yellow-legged frog**
   Receive the Department's one-year status review report on the petition to list foothill yellow-legged frog (*Rana boylii*) as an endangered or threatened species under the California Endangered Species Act.
   (Pursuant to Section 2074.6, Fish and Game Code)

4. **Executive director's report**
   Receive an update from the executive director on staffing and legislative information.

   (A) Staff report
   (B) Legislative report, federal regulatory notices, and possible action
      I. Discuss AB 1080 and SB 54 and consider authorizing a comment letter
      II. Discuss Pacific Fishery Management Council consideration of authorizing pelagic fishing using longline gear and consider submitting a comment letter

5. **Tribal Committee**
   Discuss updates and recommendations from the October 8, 2019 committee meeting. Consider approving new topics to address at a future committee meeting.

   (A) October 8, 2019 meeting summary
      I. Receive and consider adopting recommendations
   (B) Work plan development
      I. Update on work plan and draft timeline
      II. Discuss and consider approving new topics

6. **Wildlife Resources Committee**
   Discuss updates and recommendations from the September 10, 2019 committee meeting. Consider approving new topics to address at a future committee meeting.

   (A) September 10, 2019 meeting summary
      I. Receive and consider adopting recommendations
   (B) Work plan development
      I. Update on work plan and draft timeline
      II. Discuss and consider approving new topics

7. **Possession of nongame animals (nutria)**
   Discuss proposed changes to possession of nongame animals regulations, in order to exclude nutria (*Myocastor coypus*) from the list of nongame animals that can be possessed alive with a special permit.
   (Section 473, Title 14, CCR)

8. **Wildlife and inland fisheries items of interest from previous meetings**
   These items are generally updates on agenda topics recently heard before the Commission.

   (A) Update on stakeholder discussions related to the Commission's draft Delta Fisheries Management Policy and existing Striped Bass Policy

9. **Wildlife and inland fisheries petitions for regulation change**
Consider requests submitted by members of the public to adopt, amend, or repeal a regulation.
(Pursuant to Section 662, Title 14, CCR)

(A) Action on current petitions
  I. Petition #2019-013: Authorize falconers and raptor propagators to receive non-releasable raptors from rehabilitation facilities
  II. Petition #2019-016 AM 1: Authorize spring bear hunting
  III. Petition #2019-017 AM 1: Establish an open archery season for bear and deer hunting in Marble Mountain and Trinity Alps wilderness areas
  IV. Petition #2019-018: Exempt ferrets from the list of restricted species

(B) Action on pending regulation petitions referred to staff or the Department for review – None scheduled at this time

10. **Wildlife and inland fisheries non-regulatory requests from previous meetings**
Consider non-regulatory requests submitted by members of the public at previous meetings.

(A) Action on non-regulatory requests
(B) Action on pending non-regulatory requests referred to staff or the Department for review

11. **Strategic planning**
Receive an update on the strategic planning process, discuss initial input received through interviews and surveys, and initial discussion about goals and objectives.

12. **Departmental informational items (wildlife and inland fisheries)**
The Department will highlight wildlife and inland fisheries items of note since the last Commission meeting.

(A) Director's report
(B) Law Enforcement Division
(C) Wildlife and Fisheries Division, and Ecosystem Conservation Division

13. **Commission administrative items**

(A) Next meeting – December 11-12, 2019 in Sacramento
(B) Rulemaking timetable updates
(C) New business

Recess

DAY 2 – OCTOBER 10, 2019; 9:00 AM

Call to order/roll call to establish quorum

14. **General public comment for items not on agenda**
Receive public comment regarding topics within the Commission's authority that are not included on the agenda.
Note: The Commission **may not** discuss or take action on any matter raised during this item, except to decide whether to place the matter on the agenda of a future meeting (sections 11125 and 11125.7(a), Government Code).

15. **Marine Resources Committee**
Discuss and consider approving draft agenda topics for the next committee meeting. Consider approving new topics to address at a future committee meeting.

    (A) Work plan development
        I. Update on work plan and draft timeline
        II. Discuss and consider approving new topics
    (B) Update on abalone fishery management plan

16. **Experimental fishing permit program (Phase 1)**
Discuss and consider adopting proposed changes to experimental fishing permit (EFP) regulations, to allow for issuing EFPs to fishermen that were issued experimental gear permits in 2018 for the box crab experimental gear permit program, as approved by the Commission.
(Adopt Chapter 5.6, Section 90; and adopt Section 704, Title 14, CCR)

17. **Pacific Herring Fishery Management Plan (FMP)**
Discuss and consider adopting the draft Pacific Herring FMP.
(Pursuant to Fish and Game Code Section 7075, et seq.)

18. **Pacific herring regulations**
Consider adopting Pacific herring sport fishing and commercial take regulations that implement the Pacific Herring FMP.
(Add sections 55.00, 55.01, and 55.02, and amend sections 27.60, 28.60, 28.62, 163, 163.1, 163.5, 164, and 705, Title 14, CCR)

19. **Malibu Oyster Company application for state water bottom lease**
Determine whether considering a new shellfish aquaculture lease offshore Malibu as applied for by Malibu Oyster Company would be in the public interest.
(Pursuant to Section 15400, Fish and Game Code)

20. **Marine items of interest from previous meetings**
These items are generally updates on agenda topics recently heard before the Commission.

(A) Update on razor clams/domoic acid

21. **Marine petitions for regulation change**
Consider requests submitted by members of the public to adopt, amend, or repeal a regulation.
(Pursuant to Section 662, Title 14, CCR)

(A) Action on current petitions
    I. Petition #2019-014: Increase restrictions on recreational take of California grunion
(B) Action on pending regulation petitions referred to staff or the Department for review – None scheduled at this time

22. **Departmental informational items (marine)**
The Department will highlight marine items of note since the last Commission meeting.

(A) Director's report
(B) Law Enforcement Division
(C) Marine Region
    I. MLMA master plan prioritization

Adjourn

EXECUTIVE SESSION

(Not Open to Public)

At a convenient time during the regular agenda of the meeting listed above, the Commission will recess from the public portion of the agenda and conduct a closed session on the agenda items below. The Commission is authorized to discuss these matters in a closed session pursuant to Government Code Section 11126, subdivisions (a)(1), (c)(3), and (e)(1), and Fish and Game Code Section 309. After closed session, the Commission will reconvene in public session, which may include announcements about actions taken during closed session.

(A) Pending litigation to which the Commission is a Party

I. Dennis Sturgell v. California Department of Fish and Wildlife, and California Fish and Game Commission (revocation of Dungeness crab vessel permit No. CT0544-T1)

II. Public Interest Coalition v. California Fish and Game Commission (CEQA compliance during adoption of dog collar regulation)

III. Aaron Lance Newman v. California Fish and Game Commission (revocation of hunting and sport fishing privileges)

IV. Adam Aliotti and Alicia Dawn, Inc. v. California Fish and Game Commission, and California Department of Fish and Wildlife (suspension of commercial fishing license and tier-1 spot prawn trap vessel permit)

V. Almond Alliance of California et al. v. California Fish and Game Commission and California Department of Fish and Wildlife (bumble bees California Endangered Species Act determination)

(B) Possible litigation involving the Commission

(C) Staffing

(D) Deliberation and action on license and permit items

I. Consider Agency Case No. 19ALJ11-FGC, the appeal filed by Darren Johnson regarding the Department’s denial of a request to renew a salmon vessel permit.

California Fish and Game Commission
2019 and 2020 Meeting Schedule

Note: As meeting dates and locations can change, please visit www.fgc.ca.gov for the most current list of meeting dates and locations.

2019			
Meeting Date	**Commission Meeting**	**Committee Meeting**	**Other Meetings**
November 5		**Marine Resources** Natural Resources Building 12th Floor Conference Room 1416 Ninth Street, Room 1206 Sacramento, CA 95814	
December 11-12	Natural Resources Building Auditorium, First Floor 1416 Ninth Street Sacramento, CA 95814		

2020			
Meeting Date	**Commission Meeting**	**Committee Meeting**	**Other Meetings**
January 16		**Wildlife Resources** Los Angeles area	
January 17		**Tribal** Los Angeles area	
February 5-6	Natural Resources Building Auditorium, First Floor 1416 Ninth Street Sacramento, CA 95814		
March 17		**Marine Resources** Justice Joseph A. Rattigan Building Conference Room 410 (4th Floor) 50 D Street Santa Rosa, CA 95404	
March 18			**Annual Tribal Planning**
April 15-16	Natural Resources Building Auditorium, First Floor 1416 Ninth Street Sacramento, CA 95814		

2020			
Meeting Date	**Commission Meeting**	**Committee Meeting**	**Other Meetings**
May 14	**Teleconference** Santa Rosa, Sacramento, Arcata, and San Diego		
May 14		**Wildlife Resources** Justice Joseph A. Rattigan Building Conference Room 410 (4th Floor) 50 D Street Santa Rosa, CA 95404	
June 24-25	Santa Ana area		
July 21		**Marine Resources** San Clemente area	
August 18		**Tribal** Fortuna area	
August 19-20	Fortuna area		
September 17		**Wildlife Resources** Natural Resources Building Redwood Room, 14th Floor 1416 Ninth Street Sacramento, CA 95814	
October 14-15	Elihu M Harris Building Auditorium 1515 Clay Street Oakland, CA 94612		
November 9		**Tribal** Monterey area	
November 10		**Marine Resources** Monterey area	
December 9-10	San Diego area		

OTHER 2019 AND 2020 MEETINGS OF INTEREST

Association of Fish and Wildlife Agencies

- No additional 2019 meetings are scheduled at this time
- March 8-13, 2020, Omaha, NE
- September 13-16, 2020, Sacramento, CA

Pacific Fishery Management Council

- November 13-20, 2019, Costa Mesa, CA
- March 3-9, 2020, Rohnert Park, CA
- April 3-10, 2020, Vancouver, WA
- June 11-18, 2020, San Diego, CA
- September 10-17, 2020, Spokane, WA

- November 13-20, 2020, Garden Grove, CA

Pacific Flyway Council

- No additional 2019 meetings are scheduled at this time
- March 2020 (date/location TBD)
- August/September 2020 (date/location TBD)

Western Association of Fish and Wildlife Agencies

- No additional 2019 meetings are scheduled at this time
- January 9-12, 2020, Monterey, CA
- July 9-14, 2020, Park City, UT

Wildlife Conservation Board

- November 21, 2019, Sacramento, CA
- No additional 2020 meetings are scheduled at this time

IMPORTANT COMMISSION MEETING PROCEDURES INFORMATION

WELCOME TO A MEETING OF THE CALIFORNIA FISH AND GAME COMMISSION

This year marks the beginning of the 150th year of operation of the Commission in partnership with the California Department of Fish and Wildlife. Our goal is the preservation of our heritage and conservation of our natural resources through informed decision making; Commission meetings are vital in achieving that goal. In that spirit, we provide the following information to be as effective and efficient toward that end. Welcome and please let us know if you have any questions.

PERSONS WITH DISABILITIES

Persons with disabilities needing reasonable accommodation to participate in public meetings or other Commission activities are invited to contact the Reasonable Accommodation Coordinator at (916) 651-1214. Requests for facility and/or meeting accessibility should be received at least 10 working days prior to the meeting to ensure the request can be accommodated.

STAY INFORMED

To receive meeting agendas and regulatory notices about those subjects of interest to you, please visit the Commission's website, www.fgc.ca.gov, to sign up on our electronic mailing lists.

SUBMITTING WRITTEN COMMENTS

The public is encouraged to comment on any agenda item. Submit written comments by one of the following methods: **E-mail** to fgc@fgc.ca.gov; **mail** to California Fish and Game Commission, P.O. Box 944209, Sacramento, CA 94244-2090; **delivery** to California Fish and Game Commission, 1416 Ninth Street, Room 1320, Sacramento, CA 95814; or **hand-deliver to a Commission meeting.** Materials provided to the Commission may be made available to the general public.

COMMENT DEADLINES

The **Written Comment Deadline** for this meeting is **5:00 p.m. on September 26, 2019.** Written comments received at the Commission office by this deadline will be made available to Commissioners prior to the meeting.

The **Late Comment Deadline** for this meeting is **noon on October 4, 2019.** Comments received by this deadline will be marked "late" and made available to Commissioners at the meeting.

After these deadlines, written comments may be delivered in person to the meeting – Please bring ten (10) copies of written comments to the meeting.

NON-REGULATORY REQUESTS

All non-regulatory requests will follow a two-meeting cycle to ensure proper review and thorough consideration of each item. All requests submitted by the **Late Comment Deadline** (or heard during public comment at the meeting) will be scheduled for receipt at this meeting, and scheduled for consideration at the next business meeting.

PETITIONS FOR REGULATION CHANGE
Any person requesting that the Commission adopt, amend, or repeal a regulation must complete and submit form FGC 1, titled, “Petition to the California Fish and Game Commission for Regulation Change” (as required by Section 662, Title 14, CCR). The form is available at https://fgc.ca.gov/Regulations/Petition-for-Regulation-Change. To be received by the Commission at this meeting, petition forms must have been delivered by the **Late Comment Deadline** (or delivered during public comment at the meeting). Petitions received at this meeting will be scheduled for consideration at the next business meeting, unless the petition is rejected under staff review pursuant to subsection 662(b), Title 14, CCR.

VISUAL PRESENTATIONS/MATERIALS
All electronic presentations must be submitted by the **Late Comment Deadline** and approved by the Commission executive director before the meeting.

1. Electronic presentations must be provided by email to fgc@fgc.ca.gov.
2. All electronic formats must be Windows PC compatible.
3. It is recommended that a print copy of any electronic presentation be submitted in case of technical difficulties.
4. A data projector, laptop and presentation mouse will be available for use at the meeting.

CONSENT CALENDAR
A summary of all items will be available for review at the meeting. Items on the consent calendar are generally non-controversial items for which no opposition has been received and will be voted upon under single action without discussion. Any item may be removed from the consent calendar by the Commission upon request of a Commissioner, the Department, or member of the public who wishes to speak to that item, to allow for discussion and separate action.

LASER POINTERS
Laser pointers may only be used by a speaker during a presentation; use at any other time may result in arrest.

SPEAKING AT THE MEETING
To speak on an agenda item, please complete a “Speaker Card" and give it to the designated staff member before the agenda item is announced. Cards will be available near the entrance of the meeting room. Only one speaker card is necessary for speaking to multiple items.

1. Speakers will be called in groups; please line up when your name is called.
2. When addressing the Commission, give your name and the name of any organization you represent, and provide your comments on the item under consideration.
3. If there are several speakers with the same concerns, please appoint a spokesperson and avoid repetitive testimony.
4. The presiding commissioner will allot between one and three minutes per speaker per agenda item, subject to the following exceptions:
    a. The presiding commissioner may allow up to five minutes to an individual speaker if a minimum of three individuals who are present when the agenda item is called have ceded their time to the designated spokesperson, and the individuals ceding time forfeit their right to speak to the agenda item.
    b. Individuals may receive advance approval for additional time to speak if requests for

additional time to speak are received by email or delivery to the Commission office by the **Late Comment Deadline**. The president or designee will approve or deny the request no later than 5:00 p.m. two days prior to the meeting.

c. An individual requiring an interpreter is entitled to at least twice the allotted time pursuant to Government Code Section 11125.7(c).

d. An individual may receive additional time to speak to an agenda item at the request of any commissioner.

5. If you are presenting handouts/written material to the Commission at the meeting, please provide ten (10) copies to the designated staff member just prior to speaking.

2. GENERAL PUBLIC COMMENT (DAY 1)

Today's Item **Information** ☒ **Action** ☐

Receive public comments, petitions for regulation change, and requests for non-regulatory actions for items not on the agenda.

Summary of Previous/Future Actions

- **Today's receipt of requests and comments** **Oct 9-10, 2019; Valley Center**
- Consider granting, denying or referring requests Dec 11-12, 2019; Sacramento

Background

This agenda item is primarily to provide the public an opportunity to address FGC on topics not on the agenda. Staff also includes written materials and comments received prior to the meeting as exhibits in the meeting binder (if received by written comment deadline), or as late comments at the meeting (if received by late comment deadline), for official FGC "receipt."

Public comments are generally categorized into three types under general public comment: (1) petitions for regulation change; (2) requests for non-regulatory action; and (3) informational-only comments. Under the Bagley-Keene Open Meeting Act, FGC cannot discuss any matter not included on the agenda, other than to schedule issues raised by the public for consideration at future meetings. Thus, petitions for regulation change and non-regulatory requests generally follow a two-meeting cycle (receipt and direction); FGC will determine the outcome of the petitions for regulation change and non-regulatory requests received at today's meeting at the next in-person FGC meeting following staff evaluation (currently Dec 11-12, 2019).

As required by the Administrative Procedure Act, petitions for regulation change will be either denied or granted and notice made of that determination. Action on petitions received at previous meetings is scheduled under a separate agenda item titled "Petitions for regulation change." Action on non-regulatory requests received at previous meetings is scheduled under a separate agenda item titled "Non-regulatory requests."

Significant Public Comments

1. New petitions for regulation change are summarized in Exhibit 1, and the original petitions are provided as exhibits 2-3.
2. No requests for non-regulatory action were received for this meeting.
3. Informational comments are provided as exhibits 4-11.

Recommendation

FGC staff: Consider whether any new future agenda items are needed to address issues that are raised during public comment.

Exhibits

1. Summary of new petitions for regulation change received by Sep 26, 2019 at 5:00 p.m.
2. Petition #2019-019 AM 1: Remove Gila monster from the list of restricted species

3. Petition #2019-020: Increase bag and possession limits for recreational brown trout within the Klamath-Trinity River Basin
4. Letter from Linda Adams, in support of the proposed approval of a permit for Trinity Alps Resort's continued use of a seasonal dam and swimming hole while the status of foothill yellow-legged frog under the California Endangered Species Act is being determined, received Jul 31, 2019; similar letter from C. Douglas Taylor supports the resort's continued use of the seasonal dam, received Aug 6, 2019
5. Email from Kathleen Roche, providing notice of intent to file a petition under the federal Endangered Species Act to list and designate critical habitat for the Shasta snow-wreath, received Aug 22, 2019
6. Email transmitting a news release from the National Park Service (NPS), providing notice that NPS has approved a Management Plan for Developed Water Sources in Mojave National Preserve, and highlighting the impact of this decision on desert bighorn sheep, received Aug 23, 2019
7. Letter from Chairman Ryan Coonerty, Santa Cruz County Board of Supervisors, in support of DFW's work to study and propose a finalized low flow target for temporary closures of recreational steelhead angling in Santa Cruz County waterways, received Sep 3, 2019
8. Email from Nancy Dunn, concerning treatment of animals and the environment by humans, received Sep 6, 2019
9. Email from Nick Buckley, expressing concern that wildlife management decisions are being made by FGC based on politics as opposed to science, received Sep 10, 2019
10. Letter from Steve Boero, owner of Triple B Ranch, providing notice of withdrawal from DFW's Private Lands Management Program, received Sep 11, 2019
11. Email from Brett Bunge, expressing concern over the statewide lead ammunition ban and difficulty in finding certain ammunition, received Sep 18, 2019

Motion/Direction (N/A)

3. FOOTHILL YELLOW-LEGGED FROG (CONSENT)

Today's Item **Information** ☒ **Action** ☐

Receive DFW's status review report on the petition from Center for Biological Diversity to list foothill yellow-legged frog (*Rana boylii*) as threatened under the California Endangered Species Act.

Summary of Previous/Future Actions

• Receive petition	Dec 14, 2016
• FGC transmits petition to DFW	Dec 22, 2016
• Publish notice of receipt of petition	Jan 20, 2017
• Received evaluation and recommendation	Apr 26-27, 2017; Van Nuys
• FGC determined listing may be warranted	Jun 21-22, 2017; Smith River
• Approved DFW's request for 6-month extension	Jun 20-21, 2018; Sacramento
• **Today receive DFW status review report**	**Oct 9-10, 2019; Valley Center**
• Determine if listing is warranted	Dec 11-12, 2019; Sacramento

Background

On Dec 14, 2016, FGC received a petition from the Center for Biological Diversity to list foothill yellow-legged frog as a threatened species under the California Endangered Species Act. On Jun 21, 2017, FGC designated foothill yellow-legged frog as a candidate species, commencing DFW's review of the status of the species as required by Fish and Game Code Section 2074.6. In Jun 2018, FGC approved DFW's request for a six-month extension of time to complete its review.

DFW has completed its review and submitted its status review report to FGC (exhibits 1 and 2). The report represents DFW's final written review of the status of foothill yellow-legged frog and is based upon the best scientific information available to DFW.

In addition to evaluating the petitioned action to list the species as threatened or endangered, DFW evaluated whether listing the species was warranted for six unique genetic clades (a clade being a group of organisms that consist of a common ancestor and all its lineal descendants). The status review contains DFW's recommendation that listing the foothill yellow-legged frog is warranted at this time for five of the six genetic clades, with three specific recommendations:

- List the Feather River and Northeast/Northern Sierra clades as threatened;
- List the East/Southern Sierra, West/Central Coast, and Southwest/South Coast clades as endangered;
- Do not list the Northernwest/North Coast clade; listing is not warranted at this time.

Fish and Game Code Section 2075 requires FGC to receive DFW's recommendation, and to schedule final consideration of the petition at its next available meeting. Based on this, FGC could consider the petition, DFW's written evaluation and status review report, written and oral comments received, and the remainder of the administrative record, to determine if listing is warranted at its Dec 11-12, 2019 meeting in Sacramento. Findings would be adopted at a future meeting.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. DFW memo transmitting status review report, received Oct 1, 2019
2. DFW status review report, dated Sep 20, 2019

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

4A. EXECUTIVE DIRECTOR'S REPORT – STAFF REPORT

Today's Item **Information ☒** **Action ☐**

Receive the executive director's staff report.

Summary of Previous/Future Actions (N/A)

Background

Staffing Update

At its Sep 3 teleconference meeting, FGC unanimously chose Melissa Miller-Henson as its new executive director. Melissa brings a wealth of experience having served in various capacities at FGC, most recently as acting executive director since Sep 2018. Recruitment efforts for a deputy executive director are underway, with a month-long recruitment period expected to close in early Nov. FGC's marine advisor Susan Ashcraft continues to serve as acting deputy executive director, with Elizabeth Pope on loan from DFW's Marine Region as acting marine advisor. And, for the new tribal advisor and tribal liaison, staff is working with DFW to determine the most appropriate classification and then can begin a recruitment process to fill the position.

After receiving over 150 applications for a seasonal clerk, staff extended an offer to Ian Williams; his first day was Oct 1. Ian received his associate's degree from Chabot College in 2017 and plans to continue his education. Following a brief orientation, Ian will assist with meeting preparation, general reception needs, and administrative tasks.

Exhibit 1 provides an overview of FGC staff time allocation across eight focal areas, and highlights key activities of interest since the Aug FGC meeting.

New Resources Building

Construction of the state's new California Natural Resources building in Sacramento reached a milestone recently with placement of the final construction beam on the 22-story building. Construction is expected to continue through 2020, with expected move-in to begin in mid-2021. Secretary for Resources Wade Crowfoot invited the directors of departments, boards, commissions and conservancies that are administratively linked to the agency, including FGC's executive director, for a tour of the construction site and model office space in late Sep. The 900,000 square-foot building is designed to provide natural light through an open floor plan with few private offices. The building will also have ample meeting space, including a state-of-the-art 300-seat auditorium.

Paper-to-Digital Conversion Project

In preparation for the move to the new building, the California Natural Resources Agency has launched an initiative to convert most paper records to a digital format for all the offices moving to the new building. Workshops are currently underway to develop and share the plan of action. FGC has an abundance of important historical documents (including many years of meeting minutes), so this project will take considerable planning and personnel time. Staff plans to take full advantage of any resources made available.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. *Staff Report on Staff Time Allocation and Activities,* dated Sep 30, 2019

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

4B. EXECUTIVE DIRECTOR'S REPORT – LEGISLATIVE REPORT

Today's Item **Information** ☐ **Action** ☒

Review and discuss legislation and federal regulatory notices of interest and provide staff direction on potential actions.

Summary of Previous/Future Actions (N/A)

Background

FGC staff has prepared a list of state and federal legislation that may affect FGC's resources and workload or be of interest (below). DFW has provided a report on state bills it has identified as being of interest, including the current status of each (Exhibit 1).

Today is an opportunity for FGC to provide direction to staff concerning proposed legislation and regulatory actions. At any meeting, FGC may direct staff to provide information to or share concerns with bill authors or regulatory agencies. FGC members may also take positions on bills at the same meeting an update is provided.

State Legislation

Legislative Calendar Highlights for 2019-2020

- Last day for any bill to pass. Interim recess began upon adjournment — Sep 13, 2019
- Last day for Governor to sign or veto bills passed by the legislature on or before Sep 13 and in the Governor's possession after Sep 13 — Oct 13, 2019
- Statutes take effect — Jan 1, 2020
- Legislature reconvenes — Jan 6, 2020

Bills Introduced during the 2019-2020 Session

A number of the state bills identified in DFW's report (Exhibit 1) may affect FGC's resources and workload or are potentially of interest; listed below are those assembly bills (AB) or sentate bills (SB) that have been vetoed or chaptered, or are enrolled and awaiting Governor Newsom's signature.

- AB 44 (Friedman) Fur products: prohibition (Enrolled)
- AB 273 (Gonzalez) Fur-bearing and nongame mammals: recreational and commercial fur trapping: prohibition (Chaptered)
- AB 454 (Kalra) Migratory birds: California Migratory Bird Protection Act (Chaptered)
- AB 834 (Quirk) Freshwater and Estuarine Harmful Algal Bloom Program (Chaptered)
- AB 1254 (Kamlager-Dove) Bobcats: take prohibition: hunting season: management plan (Enrolled)
- AB 1260 (Maienschein) Endangered wildlife (Enrolled)

- SB 1 (Atkins) California Environmental, Public Health, and Workers Defense Act of 2019 (Vetoed)
- SB 62 (Dodd) Endangered species: accidental take associated with routine and ongoing agricultural activities: state safe harbor agreements (Chaptered)
- SB 262 (McGuire) Commercial fishing: landing fees: sea cucumbers (Enrolled)
- SB 307 (Roth) Water conveyance: use of facility with unused capacity (Chaptered)
- SB 395 (Archuleta) Wild game mammals: accidental taking and possession of wildlife: collision with a vehicle: wildlife salvage permits (Enrolled)

Other state bills not in Exhibit 1 that commissioners requested be included for discussion purposes:

- SB 54 *(Allen) Solid waste: packaging and products.* Introduced 12/11/2018. Status: Asm Committee on Natural Resources: Read second time. Ordered to third reading.
- AB 1080 *(Gonzalez) Solid waste: packaging and products*. Introduced 02/21/2019. Status: 09/14/19: Sen Committee on Environmental Quality: Measure returned to Senate floor for consideration. Ordered to inactive file at the request of Senator Bradford.

  Summary: These two bills are identical. Would require the California Department of Resources Recycling and Recovery (CalRecycle) to administer a regulatory program concerning use of single-use packaging and single-use products by producers, retailers, and wholesalers, and to finalize an implementation plan by January 1, 2023 and adopt regulations to that effect before January 1, 2024. The bills would additionally require CalRecycle to ensure that all single-use packaging and priority single-use products that are manufactured on or after January 1, 2030 and offered for sale, sold, distributed or imported in or into California are recyclable or compostable, and to achieve and maintain a statewide 75% reduction of the waste generated from single-use packaging and priority single-use products by January 1, 2030 (see Exhibits 2 and 3).

Federal Legislation

- *H.R. 30 (SAVES Act):* Rep. Louie Gohmert (TX-1). Status: House – 02/05/2019. Committeee on Natural Resources. Referred to the Subcommittee on Water, Oceans, and Wildlife.

  Summary: Limits the protection of endangered and threatened species to species that are native to the United States, thus removing protection given to non-native species in the United States that are listed as threatened or endangered.
- *H.R. 548 (FISH Act):* Rep. Ken Calvert (CA-42). Status: House – 02/04/2019. Committee on Natural Resources. Referred to the Subcommittee on Water, Oceans, and Wildlife.

  Summary: Amends the Endangered Species Act of 1973 to vest in the Secretary of the Interior functions under that Act with respect to species of fish that spawn in fresh or estuarine waters and migrate to ocean waters, and species of fish that spawn in ocean waters and migrate to fresh waters.

- *H.R. 1240 (Young Fishermen's Development Act of 2019):* Rep. Don Young (AK-At Large). Status: House – 05/08/2019. House Natural Resources Subcommittee on Water, Oceans, and Wildlife. Subcommittee hearings held.

  Summary: Effort to preserve United States fishing heritage through a national program dedicated to training and assisting the next generation of commercial fishermen.

- *H.R. 3742 (Recovering America's Wildlife Act (RAWA)):* Rep. Debbie Dingell (MI-12). Status: House – 07/29/2019. Committee on Natural Resources. Referred to the Subcommittee on Water, Oceans, and Wildlife.

  Summary: Amends the Pittman-Robertson Wildlife Restoration Act to make supplemental funds available for management of fish and wildlife species of greatest conservation need as determined by State fish and wildlife agencies, and for other education and enforcement related purposes. The Secretary of the Treasury shall annually transfer $1.3 billion to a fund established for the management and implementation of wildlife and habitat conservation and restoration programs.

- *S. 2092 (Modernizing the Pittman-Robertson Fund for Tomorrow's Needs Act):* Senator Jim Risch (ID). Status: Senate – 07/11/2019. Read twice and referred to the Committee on Environment and Public Works.

  Summary: Provides flexibility to state agencies to use Pittman-Robertson funds for the recruitment, retention, and reactivation of hunters and recreational shooters. The bill does not increase taxes or existing user fees, but would allow state fish and wildlife agencies to use existing revenues in new ways. This legislation is identical to H.R. 877 that was introduced earlier this year by Representatives Austin Scott (GA), Mark Veasey (TX), Debbie Dingell (MI), and Richard Hudson (NC).

Federal Regulatory Notices and Other Actions

Federal scoping has been initiated for authorizing shallow-set longline gear for pelagic fishing outside of the U.S. West Coast exclusive economic zone (EEZ).

- The Pacific Fishery Management Council (PFMC) is currently revisiting authrorization of pelagic shallow-set longline fishing outside of the EEZ, commencing with a scoping session scheduled for its Nov 14-20, 2019 meeting in Costa Mesa.
- Under the federal Highly Migratory Species Fishery Management Plan (FMP), shallow-set longline gear, used to target swordfish, is prohibited based on the federal Endangered Species Act (ESA) Section 7 consultation for the original FMP implementation. An FMP amendment would be required to authorize this gear type while addressing concerns associated with the current prohibition.
- Authorization was originally considered by PFMC in 2009, but it selected the no-action alternative due to bycatch concerns.
- PFMC is reconsidering its 2009 position in light of current conditions, as discussed in Sep 2018 (exhibits 4-5); conditions include West Coast landings by Hawaii-permitted shallow-set longline vessels. Vessels permitted under the Western PFMC's Pelagics Fishery Ecosystem Plan are permitted to fish with shallow-set longline gear outside the west

coast EEZ—both east and west of 150 W longtitude—and land those fish in West Coast ports.

- At the Aug 2019 FGC meeting, stakeholders requested that FGC write a letter regarding potential authorization of this gear.
- In the past, FGC has expressed concern about fishery gear types that have a high bycatch level, notably of ESA species, while also expressing a desire to support more sustainable commercial fishing in California and the United States and reduce the amount of fish imported from other countries with less stringent resource protections.

Significant Public Comments

Two requests made in Aug during public comment were added to the agenda for consideration at this meeting:

1. A stakeholder highlighted SB 54 and AB 1080 related to single-use plastics and requested that FGC write a letter to Governor Newsom in support of signing SB 54 and AB 1080.
2. A stakeholder expressed concern over PFMC scoping for potential authorization of a pelagic longline fishery outside of the EEZ, and asked FGC to write letter to PFMC. The commenter suggested that the gear type is no longer appropriate to consider outside the EEZ because of continued bycatch impacts.

Recommendation

FGC staff: Authorize the executive director to work with President Sklar to draft and send comment letters to: (1) Governor Newsom and the bill authors of SB 54 and AB 1080 expressing conceptual support for the statutory language; and (2) PFMC regarding its consideration of authorizing pelagic fishing using longline gear. Provide direction on the content of the letters.

Exhibits

1. DFW legislative report, dated Sep 30, 2019
2. SB 54 as compared to today's law, amended Sep 10, 2019
3. AB 1080 as compared to today's law, amended Sep 9, 2019
4. PFMC's draft Swordfish Management and Monitoring Plan (SMMP), Sep 2018
5. National Marine Fisheries Service report on the SMMP, Sep 2018

Motion/Direction

Moved by ______________ and seconded by ______________ that the Commission approves delegating authority to its executive director to work with President Sklar to draft and send a comment letter to Governor Newsom based on themes discussed today regarding support for signing Senate Bill 54 and Assembly Bill 1080.

AND

Moved by _____________ and seconded by _____________ that the Commission approves delegating authority to its executive director to work with President Sklar to draft and send a comment letter based on themes discussed today to the Pacific Fishery Management Council regarding its consideration of authorizing pelagic fishing using longline gear.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

5. TRIBAL COMMITTEE (TC)

Today's Item **Information** ☐ **Action** ☒

Receive summary from the Oct 8, 2019 TC meeting and potentially adopt TC recommendations. Receive update on TC work plan and draft timeline. Discuss and consider approving new topics for TC review.

Summary of Previous/Future Actions

• Most recent TC meeting	Oct 8, 2019; TC, Valley Center
• **Today consider TC recommendations and potential new topics**	**Oct 9-10, 2019; Valley Center**
• Next TC meeting	Jan 17, 2020; TC, Los Angeles area

Background

TC Work Plan and Timeline

TC works under FGC direction to set and accomplish its work plan (Exhibit 1). The agenda for the Oct 8 TC meeting (Exhibit 2) included five substantive items:

1. Discuss a co-management definition
2. Discuss potential commercial kelp and algae harvest regulation changes
3. Recommendation for DFW-managed lands regulations
4. Recommendation for changes to FGC meeting procedures regulations related to TC
5. Discuss potential topics for the annual FGC tribal planning meeting

In addition, TC received updates from FGC staff, FGC Marine and Wildlife resource committees, and other state agencies, as well as updates on the effort to develop simplified statewide inland sport fishing regulations.

During today's agenda item, a verbal report will be provided about the Oct 8 TC meeting and any resulting recommendations for FGC consideration.

TC Workgroup

As requested by TC and approved by FGC in Jun 2019, staff hosted a webinar/teleconference with representatives of California tribes and tribal communities to further progress on discussions around a co-management definition and potential commercial kelp and algae harvest management regulation changes. A half-dozen representatives participated with staff.

New TC Topics

No new topics are proposed by staff at this time.

Significant Public Comments (N/A)

Recommendation

Consider recommendations developed on Oct 8, which will be presented verbally to FGC today.

Exhibits

1. TC work plan, updated Sep 2019
2. Agenda for Oct 8, 2019 TC meeting

Motion/Direction

Moved by ____________ and seconded by ____________ that the Commission approves the ____________ recommendations from the October 8, 2019 Tribal Committee meeting.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

6. WILDLIFE RESOURCES COMMITTEE (WRC)

Today's Item **Information ☐** **Action ☒**

Receive summary from the Sep 10, 2019 WRC meeting and potentially approve WRC recommendations. Receive update on WRC work plan and timeline. Discuss and potentially approve new topics for WRC review.

Summary of Previous/Future Actions

• Most recent WRC meeting	Sep 10, 2019; WRC, Santa Rosa
• **Today consider WRC recommendations and potential new topics**	**Oct 9-10, 2019; Valley Center**
• Next WRC meeting	Jan 16, 2020; WRC, Los Angeles area

Background

WRC works under FGC direction to set and accomplish its work plan (Exhibit 2).

Meeting Summary

WRC met on Sep 10, 2019 and covered the following topics:

- Initial vetting for upland game bird hunting
- Review and recommendations for:
  - mammal hunting,
  - waterfowl hunting,
  - Central Valley sport fishing, and
  - Klamath River Basin sport fishing
- Update on simplification of statewide inland fishing regulations
- Update on bullfrogs and non-native turtle stakeholder engagement process

A written summary of the meeting is provided in Exhibit 1.

WRC Recommendations

Based on the meeting discussions, WRC has two recommendations for FGC consideration:

1. WRC recommends that FGC support the proposed regulation changes for mammal hunting, waterfowl hunting, Central Valley sport fishing, and Klamath River Basin sport fishing for the 2020-21 seasons, as recommended by DFW, and asked DFW to consider a two-week extension to the Central Valley sport fishing season on the Sacramento River.
2. WRC recommends that FGC schedule a special WRC meeting in Mar 2020, with a date to be determined, focused on simplification of statewide inland fishing regulations proposals.

Significant Public Comments (N/A)

Recommendation

FGC staff: Approve committee recommendations as described.

Exhibits

1. Summary of Sep 10, 2019 WRC meeting
2. WRC work plan, updated Sep 30, 2019

Motion/Direction

Moved by __________ and seconded by __________ that the Commission approves the recommendations from the Sep 10, 2019 Wildlife Resources Committee meeting.

OR

Moved by __________ and seconded by __________ that the Commission approves the recommendations from the Sep 10, 2019 Wildlife Resources Committee meeting, except for ___________________.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

7. POSSESSION OF NONGAME ANIMALS (NUTRIA)

Today's Item **Information** ☒ **Action** ☐

Discuss proposed changes to possession of nongame animal regulations, in order to exclude nutria from the list of nongame animals that can be possessed alive with a special permit.

Summary of Previous/Future Actions

- Notice hearing Aug 7-8, 2019; Sacramento
- **Today's discussion hearing** Oct 9-10, 2019; Valley Center
- Adoption hearing Dec 11-12, 2019; Sacramento

Background

Nutria (*Myocastor coypus*) is a mammal of the order Rodentia; subsection 671(c)(2)(J) designates all rodents (with certain exceptions), including nutria, as "detrimental animals." Nutria are semi-aquatic rodents native to South America and are a highly destructive, invasive species. The detrimental impacts caused by nutria include harm to the State's wildlife, wetland habitats, waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture. Since early 2017, DFW has been planning and implementing eradication efforts with multiple partners in response to the discovery of a pregnant nutria in a managed wetland in the San Joaquin Valley.

Under current law, possession of live nutria can be authorized by DFW under a restricted species permit. DFW has identified that, in addition to eradication efforts already underway, banning the possession of any live nutria is necessary to help prevent new introductions of nutria in the state. The proposed regulation (exhibits 1 and 2) would amend Section 473 to make possession of live nutria unlawful and authorize DFW to deny any application for the possession of live nutria (see Exhibit 5).

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. DFW memo transmitting initial statement of reasons (ISOR), received Jul 11, 2019
2. ISOR
3. Notice of exemption
4. Economic and fiscal impact statement (Std. 399)
5. DFW presentation from Aug 7, 2019 notice hearing

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

8. ITEMS OF INTEREST FROM PREVIOUS MEETINGS (WILDLIFE AND INLAND FISHERIES)

Today's Item **Information** ☒ **Action** ☐

This is a standing agenda item to provide FGC with updates on items of interest from previous meetings. For this meeting: Update on stakeholder discussions related to FGC's draft Delta Fisheries Management Policy and existing Striped Bass Policy.

Summary of Previous/Future Actions

• Delta Fisheries Forum	May 24, 2017; Sacramento
• WRC vetting of draft policy	Sep 2018 – May 2019
• FGC accepted WRC recommendation to schedule	Jun 12-13, 2019; Redding
• Discussion of draft policy and potential adoption	Aug 7-8, 2019; Sacramento
• **Today's update**	**Oct 9-10, 2019; Valley Center**
• Discussion of revised draft policy and potential changes to existing policy	Dec 11-12, 2019; Sacramento

Background

This item is an opportunity for staff to provide follow-up information on wildlife and inland fisheries topics previously before FGC.

At its Aug 2019 meeting, FGC received a revised draft Delta Fisheries Management Policy for discussion and potential adoption; see Exhibit 1 for further background. Following extensive public comment at the meeting, FGC accepted a staff recommendation to postpone discussion of the draft policy until the Dec 2019 meeting, in order to continue stakeholder discussions with FGC staff and DFW regarding both the draft policy and existing FGC Striped Bass Policy, and to invite a broader array of participants. FGC requested that staff provide at the Oct 2019 FGC meeting an update on the progress of stakeholder discussions on revising the draft policies.

To facilitate broader stakeholder input, staff scheduled a meeting for Sep 30 in Sacramento and publicized it through the FGC listserv (Exhibit 2); nine representatives participated from various organizations representing fishing and water interests. At today's meeting, staff will report on outcomes of the Sep 30 meeting and progress in developing draft revised policies.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. Staff summary from Aug 7-8 2019 FGC meeting, for background purposes only
2. FGC staff email invitation to stakeholders for Sep 30 Delta Fisheries Management Policy meeting, sent Sep 26, 2019

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

9. WILDLIFE AND INLAND FISHERIES PETITIONS FOR REGULATION CHANGE

Today's Item **Information** ☐ **Action** ☒

This is a standing agenda item for FGC to act on regulation petitions from the public that are related to wildlife and inland fisheries issues. For this meeting:

(A) Action on petitions for regulation change received at the Aug 2019 meeting

(B) Pending regulation petitions referred to FGC staff and DFW for review – *none scheduled*

Summary of Previous/Future Actions

(A)

- Receive petitions — Aug 7-8, 2019; Sacramento
- **Today's actions on petitions — Oct 9-10, 2019; Valley Center**

(B)

N/A

Background

Pursuant to Section 662, any request for FGC to adopt, amend, or repeal a regulation must be submitted on form FGC 1, "Petition to the California Fish and Game Commission for Regulation Change" (Section 662, Title 14). Petitions received at an FGC meeting are scheduled for consideration at the next business meeting under (A), unless the petition is rejected under 10-day staff review as prescribed in subsection 662(b). A petition may be (1) denied, (2) granted, or (3) referred to committee, staff or DFW for further evaluation or information-gathering. Referred petitions are scheduled for action under (B) once the evaluation is completed and a recommendation made.

(A) ***Petitions for regulation change***

Four petitions received at the Aug meeting are scheduled for action:

I. *Petition #2019- 013: Authorize falconers and raptor propagators to receive non-releasable raptors from rehabilitation facilities (Exhibit A2)*

II. *Petition #2019-016 AM 1: Authorize spring bear hunting (Exhibit A3)*

III. *Petition #2019-017 AM 1: Establish an open archery season for bear and deer hunting in Marble Mountain and Trinity Alps wilderness areas (Exhibit A4)*

IV. *Petition #2019-018: Exempt ferrets from the list of restricted species (Exhibit A5)*

Staff recommendations and rationales are provided in Exhibit A1. See Exhibit A6 for background on the staff recommendation for Petition #2019-018.

(B) ***Pending regulation petitions.*** This is an opportunity for staff to provide a recommendation on petitions previously referred by FGC to staff, DFW, or a committee for review.

No pending regulation petitions are scheduled for action at this meeting.

Significant Public Comments

1. One comment on Petition #2019-016 (spring bear hunting) was received, in support of a spring bear hunt as proposed in the petition (Exhibit A7).
2. Several comments on Petition #2019-018 (ferrets) were received with the following perspectives:
   a. The executive director of United California Ferret Alliance states that Petition #2019-018 comes from a separate, independent organization. She recounts her organization's efforts to pursue legislation to legalize ferrets as pets (Exhibit A8).
   b. Several ferret organizations and individual commenters in support of the petition state that ferrets are domesticated and provide substantiating information, links to websites, and journal articles in support of that view (exhibits A9-A14); dispute that ferrets cause environmental damage (Exhibit A15); and urge FGC to base its decisions on sound science (Exhibit A16).
   c. Commenters sent 199 additional emails in support of the petition, stating that domestic ferrets are not wild animals (see Exhibit A17 for a sample email).

Recommendation

(A) ***FGC staff:*** Adopt staff recommendations as reflected in Exhibit A1.

Exhibits

A1. Table of petitions and staff recommendations received at Aug 2019 FGC meeting, revised Sep 27, 2019
A2. Petition #2019- 013, received Jun 10, 2019
A3. Petition #2019-016 AM 1, received Jul 31, 2019
A4. Petition #2019-017 AM 1, received Jul 31, 2019
A5. Petition #2019-018, received Jul 10, 2019
A6. FGC memo regarding considerations for ferret legalization, associated with Petition #2016-008, dated Oct 10, 2016 (provided for background purposes)
A7. Email from Gary Ward, received Sep 24, 2019
A8. Email from Megan Mitchell, United California Ferret Alliance, received Jul 11, 2019
A9. Email from the World Ferret Union and the World Ferret Information Centre, received Sep 16, 2019
A10. Email from Karl A. Swartz, received Sep 8, 2019
A11. Email from Kathleen Dodson, received Sep 9, 2019
A12. Email from Josh Hall, received Sep 6, 2019
A13. Email from Donna Ferreira, received Sep 23, 2019
A14. Email from Mishele Barker, received Sep 25, 2019
A15. Email from Monica Hail, received Sep 17, 2019
A16. Email from Rene Gandolfi, received Sep 23, 2019
A17. Sample email, from Juliana Lenny, received Sep 8, 2019

Motion/Direction

Moved by ____________ and seconded by ____________ that the Commission adopts the staff recommendations as reflected in Exhibit A1.

OR

Moved by ____________ and seconded by ____________ that the Commission adopts the staff recommendations as reflected in Exhibit A1, except for Petition #________ for which the action is ______________________.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

10. WILDLIFE AND INLAND FISHERIES NON-REGULATORY REQUESTS

Today's Item **Information** ☐ **Action** ☒

This is a standing agenda item for FGC to act on non-regulatory requests from the public that concern wildlife and inland fisheries. For this meeting:

(A) Action on non-regulatory requests received for the Aug 2019 meeting

(B) Update on pending non-regulatory requests referred to FGC staff or DFW for review – *none scheduled*

Summary of Previous/Future Actions

(A)

- FGC receipt of requests — Aug 7-8, 2019; Sacramento
- **Today's action on requests** — **Oct 9-10, 2019; Valley Center**

(B)

N/A

Background

FGC provides direction regarding requests from the public received by mail and email and during general public comment at the previous FGC meeting. Public requests for non-regulatory action follow a two-meeting cycle to ensure proper review and consideration.

(A) ***Non-regulatory requests.*** Non-regulatory requests scheduled for consideration today were received at the Aug 2019 meeting in one of three ways: (1) submitted by the comment deadline and published as tables in the meeting binder, (2) submitted by the late comment deadline and delivered at the meeting, or (3) received during public comment.

Today, five non-regulatory requests received at the Aug 2019 meeting are scheduled for action. Exhibit A1 summarizes and contains staff recommendations for each request, and one original written request is provided as Exhibit A2.

(B) ***Pending non-regulatory requests.*** This item is an opportunity for staff to provide a recommendation on non-regulatory requests that were scheduled for action at a previous meeting and referred by FGC to staff or DFW for further review.

There are no pending non-regulatory requests for today.

Significant Public Comments (N/A)

Recommendation

FGC staff: Adopt staff recommendations for Aug 2019 non-regulatory requests (Exhibit A1).

Exhibits

1. List of non-regulatory requests and staff recommendations for requests received through Aug 7, 2019, dated Sep 30, 2019

2. Email from Danny Offer, Platinum Advisors, on behalf of Chairman Curt Hagman, San Bernardino County Board of Supervisors, received Aug 7, 2019

Motion/Direction

(A) Moved by ____________ and seconded by ____________ that the Commission adopts the staff recommendations for actions on August 2019 non-regulatory requests.

OR

Moved by ____________ and seconded by ____________ that the Commission adopts the staff recommendations for actions on August 2019 non-regulatory requests, except for item(s) ____________ for which the action is ____________.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

11. STRATEGIC PLANNING

Today's Item **Information** ☒ **Action** ☐

This is a standing agenda item for 2018-19 FGC meetings as FGC develops a new strategic plan. Staff will provide an update on current progress.

Summary of Previous/Future Actions (N/A)

• Adopted mission, vision, and core values	Dec 12-13, 2018; Oceanside
• Received updates on second phase	Feb, Apr, Jun 2019; various
• Discussed seven key questions	Aug 7-8, 2019; Sacramento
• **Today's update**	**Oct 9-10, 2019; Valley Center**
• Discuss potential goals and objectives	Dec 11-12, 2019; Sacramento

Background

In anticipation of FGC's upcoming 150-year anniversary in 2020, a strategic planning process was initiated in early 2018 (Exhibit 1 provides additional background). In the first of a three-phase process, FGC reassessed its mission and vision, and developed a set of core values, in concert with staff and stakeholders. Adopted in Dec 2018, the revised mission, vision, and new core values (Exhibit 2) are serving to guide a forward-thinking update to the strategic plan.

In Jun 2019, staff reported that the second phase of the planning process was ramping up, to consist primarily of data gathering and synthesis with staff, stakeholders and commissioners. The Aug 2019 FGC discussion was held in a workshop format so that commissioners, staff, and stakeholders could have a direct dialogue about several key questions related to FGC's performance and priorities (Exhibit 3).

After the Aug discussion, staff finalized an online survey designed to solicit broader input on key questions, which will be sent to a randomly selected subset of FGC's mailing lists; the survey commences Oct 4 and will be available through Oct 20. Staff is currently scheduling in-depth interviews with individual commissioners, leadership from DFW and other sister agencies, and non-governmental organization representatives.

The information gathered during this phase will be analyzed and used to help guide development of draft goals and objectives for FGC consideration. In anticipation of this process, staff has prepared a document that provides samples of goals and objectives from strategic plans of other fish and game commissions in the United States as well as the U.S. Fish and Wildlife Service; in some cases, there is not a separate fish and game commission from the state's wildlife management agency (Exhibit 4). FGC is scheduled to review and discuss possible goals and objectives at its Dec 2019 meeting.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. Staff summary from Agenda Item 17, Strategic Planning, Aug 22-23, 2018 (for background only)
2. FGC mission, vision and core values, adopted Dec 13, 2018
3. Staff summary from Agenda Item 15, Strategic Planning, Aug 7-8, 2019 (for background only)
4. Samples of strategic plan goals and objectives from other states (to be presented during meeting)

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

12. DEPARTMENT INFORMATIONAL ITEMS (WILDLIFE AND INLAND FISHERIES)

Today's Item **Information** ☒ **Action** ☐

This is a standing agenda item to receive and discuss informational updates from DFW.

(A) Director's report

(B) Law Enforcement Division

(C) Wildlife and Fisheries Division and Ecosystem Conservation Division

Summary of Previous/Future Actions (N/A)

Background

Verbal reports on items of interest since the last FGC meeting are expected at the meeting for items (A) through (C). DFW news releases of particular interest are provided as exhibits B1 and C1-C3.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

B1. DFW news release: *CDFW and Partners Remove Illegal Cannabis Grows Near Sensitive Wildlife Habitat in Trinity and Shasta Counties,* Sep 19, 2019

C1. DFW news release: *CDFW Steps in to Protect Animals at Wildlife Waystation*, Aug 13, 2019

C2. DFW news release: *CDFW Expands Statewide Sampling for Chronic Wasting Disease [in deer and elk herds]*, Sep 19, 2019

C3. DFW news release: *Paiute Cutthroat Trout Reintroduced to Native Habitat in High Sierra Wilderness*, Sep 23, 2019

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

13A. ADMINISTRATIVE ITEMS – NEXT MEETING

Today's Item **Information** ☐ **Action** ☒

This is a standing agenda item to review logistics and approve draft agenda items for the next FGC meeting and consider any changes to meeting dates or locations.

Summary of Previous/Future Actions (N/A)

Background

The next FGC meeting is scheduled for Dec 11-12, 2019 in Sacramento. Staff does not anticipate any special logistics for this meeting.

Potential agenda items for the Dec meeting are provided in Exhibit 1 for consideration and potential approval.

FGC staff would also like to highlight the possibility of a field trip to view a grunion run in southern California in conjunction with the Jun 2020 FGC meeting.

Significant Public Comments (N/A)

Recommendation

FGC staff: Approve potential agenda items for the Dec 11-12, 2019 FGC meeting.

Exhibits

1. Potential agenda items for the Dec 11-12, 2019 FGC meeting

Motion/Direction

Moved by _____________ and seconded by _____________ that the Commission approves the agenda items for the December 11-12, 2019 Commission meeting, as amended at this meeting.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

13B. ADMINISTRATIVE ITEMS – RULEMAKING TIMETABLE

Today's Item **Information** ☐ **Action** ☒

Review and consider approving requested changes to the perpetual timetable for anticipated regulatory actions.

Summary of Previous/Future Actions

- FGC approved changes to rulemaking timetable — Aug 7-8, 2019; Sacramento
- **Today consider approving proposed changes to the rulemaking timetable** — **Oct 9-10, 2019; Valley Center**

Background

FGC maintains a perpetual timetable for anticipated regulatory actions. At each FGC meeting, staff provides the latest approved timetable with requests for changes from FGC staff and/or DFW (Exhibit 1) highlighted in bolded and underlined blue text (Exhibit 2).

FGC staff made two changes:

- To assist in tracking consideration of granted petitions for regulation changes, FGC staff made an administrative change to the rulemaking timetable to include granted petition numbers where the petitions are expected to be considered.
- The proposed special WRC meeting for Mar 2020, recommended by WRC under Agenda Item 6 for this meeting, is reflected with the exact date to be determined.

DFW makes three requests:

- Move *Simplification of Statewide Inland Fishing Regulations* from TBD to scheduled dates, with final WRC review and recommendation in Mar 2020 (if approved under Agenda Item 6) and rulemaking notice in Jun 2020, discussion in Aug 2020, and adoption in Oct 2020.
- Move up extensions of the current *Klamath River Basin 2084 Emergency* rulemaking*,* which is set to expire on Dec 24, 2019, with the first 90-day extension scheduled for Dec 2019 and a second 90-day extension scheduled for Feb 2020. At the same time, DFW is preparing to submit a full Klamath River Basin 2084 regular rulemaking to implement a certificate of compliance; DFW proposes to schedule this for notice in Dec 2019, discussion in Feb 2020, and adoption in Apr 2020. The proposed actions will ensure continuous coverage under emergency regulations until the regular rulemaking is completed and approved.
- Remove *Upland Game Bird* regulations from the calendar for 2020 since there are no proposed changes for that year.

Significant Public Comments (N/A)

Recommendation

FGC staff: Adopt proposed changes to the timetable for anticipated regulatory actions (Exhibit 2) and provide direction on scheduling any rulemaking changes identified during the meeting.

Exhibits

1. DFW memo, received Sep 26, 2019
2. Proposed timetable for anticipated regulatory actions, dated Sep 30, 2019

Motion/Direction

Moved by ___________ and seconded by ____________ that the Commission approves the proposed changes to the rulemaking timetable as discussed today.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

13C. ADMINISTRATIVE ITEMS – NEW BUSINESS

Today's Item **Information ☒** **Action ☐**

This is a standing agenda item to allow Commissioners to bring new items of business to FGC.

Summary of Previous/Future Actions (N/A)

Background (N/A)

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits (N/A)

Motion/Direction (N/A)

Author: *Sergey Kinchak*

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14. GENERAL PUBLIC COMMENT (DAY 2)

Today's Item **Information** ☒ **Action** ☐

Receive public comments, petitions for regulation change, and requests for non-regulatory actions for items not on the agenda.

Summary of Previous/Future Actions

- **Today's receipt of requests and comments** **Oct 9-10, 2019; Valley Center**
- Consider granting, denying or referring Dec 11-12, 2019; Sacramento

Background

This agenda item is primarily to provide the public an opportunity to address FGC on topics not on the agenda. Staff also includes written materials and comments received prior to the meeting as exhibits in the meeting binder (if received by written comment deadline), or as late comments at the meeting (if received by late comment deadline), for official FGC "receipt."

Public comments are generally categorized into three types under general public comment: (1) petitions for regulation change; (2) requests for non-regulatory action; and (3) informational-only comments. Under the Bagley-Keene Open Meeting Act, FGC cannot discuss any matter not included on the agenda, other than to schedule issues raised by the public for consideration at future meetings. Thus, petitions for regulation change and non-regulatory requests generally follow a two-meeting cycle (receipt and direction); FGC will determine the outcome of the petitions for regulation change and non-regulatory requests received at today's meeting at the next in-person FGC meeting following staff evaluation (currently Dec 11-12, 2019).

As required by the Administrative Procedure Act, petitions for regulation change will be either denied or granted and notice made of that determination. Action on petitions received at previous meetings is scheduled under a separate agenda item titled "Petitions for regulation change." Action on non-regulatory requests received at previous meetings is scheduled under a separate agenda item titled "Non-regulatory requests."

Significant Public Comments

All written comments were summarized and provided as exhibits under Agenda Item 2, "General public comment for items not on agenda".

Recommendation

FGC staff: Consider whether any new future agenda items are needed to address issues that are raised during public comment.

Exhibits

See exhibits for Agenda Item 2.

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

15. MARINE RESOURCES COMMITTEE (MRC)

Today's Item **Information** ☐ **Action** ☒

(A) Discuss and consider approving draft agenda topics for the next MRC meeting. Consider approving new topics for MRC to address at a future meeting.

(B) Receive update on red abalone fishery management plan (FMP)

Summary of Previous/Future Actions

• Most recent MRC meeting	Jul 11, 2019; MRC, Ventura
• **Today consider approving draft MRC agenda topics**	**Oct 9-10, 2019; Valley Center**
• Next MRC meeting	Nov 5, 2019; MRC, Sacramento

Background

(A) *MRC Work Plan and Draft Timeline*

FGC directs committee work. The updated work plan in Exhibit 1 includes topics and timelines for items referred by FGC to MRC. Draft agenda topics proposed for the Nov 2019 MRC meeting are:

- Update on implementing the 2018 MLMA master plan for fisheries (standing item)
- Red abalone FMP development update (standing item)
- Update and discussion on kelp and algae commercial harvest rulemaking
- Update on FGC's Coastal Fishing Communities Project
- Discussion of whale and turtle protections in the management of Dungeness crab fisheries
- Stakeholder informational presentation on aspects of State commercial fisheries management not under FGC regulatory authority

New MRC Topics

No new topics have been identified at this time.

(B) *Update on red abalone FMP*

Although FMP development is a standing agenda item on the MRC work plan, the topic has been of broad interest to FGC. As such, an update on public engagement and FMP development will be provided at this meeting.

Significant Public Comments (N/A)

Recommendation

FGC staff: Approve the draft agenda topics for the Nov 2019 MRC meeting.

Exhibits

1. Updated MRC work plan, dated Sep 30, 2019

Motion/Direction

Moved by __________ and seconded by __________ that the Commission approves the draft agenda topics for the Nov 2019 Marine Resources Committee meeting as proposed.

16. EXPERIMENTAL FISHING PERMIT PROGRAM (PHASE 1)

Today's Item **Information** ☐ **Action** ☒

Discuss and consider adopting proposed changes to experimental fishing permit (EFP) regulations, to allow for issuing EFPs to fishermen who were issued experimental gear permits (EGPs) in 2018 for the box crab EGP program.

Summary of Previous/Future Actions

• FGC approves two-phase rulemaking approach	Jun 12-13, 2019; Redding
• DFW update and MRC discussion	Jul 11, 2019; MRC, Ventura
• Notice hearing	Aug 7-8, 2019; Sacramento
• **Today's discussion/adoption hearing**	**Oct 9-10, 2019; Valley Center**

Background

In Aug 2019, FGC authorized publishing notice of proposed adoption of sections 90 and 704, concerning the issuance of EFPs, as Phase 1 of a two-phase rulemaking process.

As described in greater detail within the staff summary for the Aug 2019 FGC meeting (Exhibit 1), DFW currently administers an EGP program for the box crab fishery, in order to research the potential for developing a new targeted fishery in California (hereinafter referred to as the box crab experimental program). In Dec 2018, pursuant to Fish and Game Code Section 8606 (2017), FGC approved eight EGPs associated with the box crab experimental program for issuance by DFW; these eight permits will expire on Mar 31, 2020.

Fish and Game Code Section 8606 was repealed effective Jan 1, 2019, thus eliminating FGC's ability to renew or authorize any new EGPs. A new Fish and Game Code Section 1022 was created, which provides for establishing an EFP program upon FGC adopting regulations. With the repeal of Section 8606, and absent regulations implementing the new Section 1022, the box crab experimental program cannot be continued beyond the Mar 31, 2020 expiration of the existing permits.

Per the two-phase rulemaking approach approved by FGC in Jun 2019 (see Exhibit 1), this Phase 1 rulemaking proposes a process for issuing EFPs pursuant to Fish and Game Code Section 1022 only to fishermen approved by FGC in Dec 2018 for box crab EGPs. Adopting the proposed regulations in this rulemaking (Phase 1) will ensure that the current box crab experimental program can continue while a larger programmatic rulemaking (Phase 2) can be developed with stakeholder engagement.

Proposed Regulations

The proposed regulations will add to Title 14 a new Chapter 5.6, Experimental Fishing Permit Program, containing new Section 90, Issuance of Experimental Fishing Permits. The proposed Section 90 will establish a process for FGC approval and DFW issuance of EFPs to those applicants previously approved to receive a box crab EGP, and includes the following concepts:

- No more than eight valid EFPs will be issued at any one time.

- An applicant shall submit a written request for an EFP at least 60 days prior to the expiration date of their current EGP.
- FGC may establish standard terms applicable to all fishery participants.
- FGC may approve the adoption, amendment, or repeal of special conditions unique to the experimental fishery set forth in Form DFW 1085 as it deems necessary for research and the conservation and management of marine resources and the environment.
- DFW shall notify a permittee at least 30 days before recommending a change to the special conditions of the EFP issued to that permittee.
- Access to future permits, if a fishery is developed, is not implied by participation in the EFP program.

The proposed regulations will also add new Section 704, Experimental Fishing Permits; Fees and Forms to Title 14, which will stipulate an annual box crab EFP fee of $4,487.75. Pursuant to Fish and Game Code, subdivision 1022(g), FGC is authorized to charge a fee as necessary to fully recover, but not exceed, all reasonable implementation and administrative costs of DFW and FGC related to the EFP. A detailed discussion of these costs can be found in the initial statement of reasons (ISOR; Exhibit 2) and economic and fiscal impact statement (Std 399; Exhibit 3).

Proposed Section 704 will also incorporate by reference the Experimental Fishing Permit Terms and Conditions Form DFW 1085 (New 08/01/2019) (Exhibit 4), which identifies the person(s) and vessel authorized to conduct activities under the EFP and specifies the standard terms and special conditions to which EFP permit holders will be subject. The proposed standard terms and special conditions are consistent with those used to issue the box crab EGPs (Exhibit 5).

California Environmental Quality Act (CEQA)

A notice of exemption (Exhibit 6) has been drafted consistent with FGC staff's recommendation to rely on two CEQA categorical exemptions (Class 6 and Class 7) for the proposed regulation changes. Staff has reviewed all of the available information possessed by FGC relevant to the issue, including the analysis and rationale presented in exhibits 6 and 7, and does not believe that reliance on these categorical exemptions is precluded by the exceptions set forth in CEQA Guidelines Section 15300.2.

Significant Public Comments

Two comments were received during the public comment period. DFW has provided a detailed summary of and response to the individual comments and, for the reasons set forth in its responses to public comments, does not believe that the comments received warrant changes to the proposed regulations (Exhibit 8).

Recommendation

FGC staff: Rely on two CEQA categorical exemptions (Class 6 and Class 7) for the proposed regulation changes and adopt the proposed regulation changes as recommended by DFW.

DFW: Adopt the proposed regulation changes as detailed in the ISOR.

Exhibits

1. Staff summary from Aug 7-8, 2019 FGC meeting (for background only)
2. ISOR
3. Economic and fiscal impact statement (Std. 399)
4. Proposed form DFW 1085, *Experimental Fishing Permit Terms and Conditions*
5. Box crab experimental gear permit terms and conditions, dated Dec 20, 2018 (for background only)
6. Draft notice of exemption
7. DFW memo transmitting ISOR and providing overview of CEQA categorical exemptions, received Jul 22, 2019
8. DFW memo responding to public comments, received Sep 25, 2019
9. DFW presentation

Motion/Direction

Moved by _____________ and seconded by _____________ that the Commission has determined, based on the record, that this approval is exempt from the California Environmental Quality Act pursuant to the guidelines in sections 15306 and 15307, Title 14, California Code of Regulations, and adopts the proposed regulations in Section 90 and Section 704, related to issuing experimental fishing permits.

17. PACIFIC HERRING FISHERY MANAGEMENT PLAN

Today's Item **Information** ☐ **Action** ☒

Discuss and potentially adopt a Pacific Herring Fishery Management Plan (FMP) and California Environmental Quality Act (CEQA) documentation.

Summary of Previous/Future Actions

• DFW updates on FMP progress	2016-2017; MRC meetings
• DFW updates and MRC recommendation	Jul 17, 2018; MRC, San Clemente
• FGC endorsed MRC recommendation	Aug 22-23, 2018; Fortuna
• Updated on FMP progress	Mar 20, 2019; MRC, Sacramento
• Received draft FMP	Jun 12-13, 2019; Redding
• Discussed draft FMP	Aug 7-8, 2019; Sacramento
• **Potentially adopt FMP/CEQA document**	**Oct 9-10, 2019; Valley Center**

Background

The Marine Life Management Act (MLMA) requires that FMPs form the primary basis for managing California's marine fisheries (Section 7072 et seq., Fish and Game Code). Pursuant to the mandates of MLMA, DFW has been developing the California Pacific Herring FMP (Herring FMP) since 2016 with a collaborative working group of herring fleet leaders, staff from conservation non-governmental organizations, and DFW. Exhibit 1 provides additional background information.

FGC received the draft Herring FMP in Jun 2019, which commenced both a 45-day CEQA public comment period that ran through Aug 1, 2019, and an FMP-specific comment period that is open through FMP adoption. A public comment letter received in Jul 2019 alerted staff that Appendix R was missing from the Jun draft Herring FMP; the missing appendix was transmitted at the Aug FGC meeting, a notice of its inclusion was sent to all draft Herring FMP commenters, and an updated draft Herring FMP was posted to FGC and DFW websites.

FGC directed staff to provide a copy of the draft Herring FMP to the California State Legislature's Joint Committee on Fisheries and Aquaculture for review prior to adoption, in fulfillment of Fish and Game Code 7078(d) (Exhibit 2). The accompanying memo identifies statutes proposed for repeal through adoption of the FMP, which establishes authority for FGC to promulgate regulations pursuant to the FMP. No comments have been received from the committee to date.

Today, DFW is requesting that FGC adopt the Oct 2019 Herring FMP as final and has provided a memo and presentation to support the request (exhibits 3-5). The draft Herring FMP has been updated to include *Appendix S: Public Comments Received, Responses, and Changes to the Draft California Pacific Herring Fishery Management Plan*, which summarizes public comments received by FGC during the public comment period, DFW responses, and changes to the Herring FMP incorporated since Jun 2019.

The Herring FMP serves as the functional equivalent of an environmental impact report under CEQA, consistent with FGC's Certified Regulatory Program, thus allowing FGC to comply with CEQA when considering and adopting the Herring FMP. If the Herring FMP is adopted, FGC will need to adopt implementing regulations, which will be considered under Agenda Item 18 – Pacific Herring Regulations (this meeting).

Significant Public Comments

1. Oceana submitted a letter with 3,091 signatures supporting adopting the Herring FMP and its implementing regulations (Exhibit 6).
2. The Environmental Action Committee of West Marin submitted a letter to reiterate its previous comments supporting the Herring FMP, the updated proposed recreational limit, and the management goals of the Herring FMP, and provided specific recommendations for implementing regulations (Exhibit 7).
3. Additional comments received during the public comment period are summarized, with responses from DFW, in Appendix S of the Oct 2019 Herring FMP (Exhibit 3).

Recommendation

FGC staff: Adopt the final draft Pacific Herring FMP as recommended by DFW.

DFW: Adopt the Oct 2019 Herring FMP with *Appendix S: Public Comments received, Responses, and Changes to the Draft California Pacific Herring Fishery Management Plan* as final.

Exhibits

1. Staff summary for Agenda Item 25, Jun 12-13, 2019 FGC meeting (for background only)
2. Memo to Joint Committee on Fisheries and Aquaculture, dated Sep 12, 2019
3. Final draft Herring FMP, including *Appendix S: Public Comments Received, Responses, and Changes to the Draft California Pacific Herring Fishery Management Plan*, dated Oct 2019
4. DFW memo transmitting the final draft Herring FMP, received Sept 25, 2019
5. DFW Presentation
6. Letter and signatures from Oceana, received Sep 24, 2019
7. Email from Ashley Eagle-Gibbs, Environmental Action Committee of West Marin, received Sep 26, 2019

Motion/Direction

Moved by________________ and seconded by________________ that the Commission finds the California Pacific Herring Fishery Management Plan as an environmental document reflects the independent judgment of the Commission; adopts the document for purposes of compliance with the California Environmental Quality Act; and adopts the final draft herring fishery management plan as presented as *Final California Pacific Herring Fishery Management Plan* consistent with the Marine Life Management Act.

OR

Moved by_______________ and seconded by_______________ that the Commission finds that the California Pacific Herring Fishery Management Plan as an environmental document reflects the independent judgment of the Commission; adopts the document for purposes of compliance with the California Environmental Quality Act; and adopts the final draft herring Fishery Management Plan as presented as the *Final California Pacific Herring Fishery Management Plan* consistent with the Marine Life Management Act with the following modifications: ___________________.

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18. PACIFIC HERRING REGULATIONS

Today's Item **Information** ☐ **Action** ☒

Discuss and consider proposed changes to adopt new and amend existing regulations to implement the *California Pacific Herring Fishery Management Plan* (Herring FMP).

Summary of Previous/Future Actions

• MRC vetting	Jul 2016–Mar 2019
• Notice hearing	Jun 12-13, 2019; Redding
• Discussion hearing	Aug 7-8, 2019; Sacramento
• **Today's adoption hearing**	**Oct 9-10, 2019; Valley Center**

Background

The draft Herring FMP (see Agenda Item 17, this meeting) initiates the process for concurrently considering and adopting regulations to implement the Herring FMP under authority established through the FMP; this includes revisions to current recreational and commercial Pacific herring regulations (sections 27.60, 28.60, 163, 163.1, 163.5, 164 and 705) and proposed new regulatory sections (Section 28.62; and Article 6, sections 55.00, 55.01 and 55.02). See the Jun 2019 FGC staff summary (Exhibit 3) for a more detailed background.

One of the significant proposed changes is new Section 28.62, related to recreational take of herring; currently there are no limits. However, DFW has proposed a daily bag limit for recreational take of herring in a range from 0-100 pounds; 100 pounds which is the equivalent of two 5-gallon buckets (approximately 260 each bucket). Today, DFW will ask FGC to adopt a recreational bag limit within the range (Exhibit 2).

At FGC's Aug 2019 meeting, DFW notified FGC that the draft Herring FMP received in Jun was missing one of its appendices, titled *Appendix R: Harvest Control Rule Framework Development and Guidance for Amending the Decision Tree*. Appendix R was added to the proposed rulemaking file in Aug, triggering a 15-day notice of availability pursuant to Government Code 11346.8. The notice was mailed to interested parties on Sep 5, 2019 and FGC staff has not received any comments to date.

For today's adoption hearing, DFW has identified two proposed changes that it considers to be errors that can be addressed if FGC selects the "no change" alternative (Exhibit 11). In a memo received Oct 1, 2019 (Exhibit 11), DFW requests that FGC select the "**no change**" alternative for two subsections, 163.1(d) and 164(d)(1):

1. ***Subsection 163.1(d)***, related to net tending distance. Members of the commercial industry members provided feedback to DFW and requested to retain the existing Title 14 language; the steering committee did not express opposition to the request.

<u>Noticed change</u>:

(d) Net Tending. Permitted vessels shall be in the immediate proximity, not exceeding one nautical mile, of any single gill net being fished.

<u>No change alternative</u> *[original text moved from Section 163(f)(2)(A)]:*

(d) Net tending. Permitted vessels shall be in the immediate proximity, not exceeding three nautical miles, of any single gill net being fished. (Exhibit 11)

2. ***Subsection 164(d)(1),*** related to herring eggs on kelp gear type, including gear allowances, proposed a rewording of the existing regulatory language with the intent of clarifying the meaning; however, the change inadvertently introduced an error and inconsistency related to the total number of allowable lines and rafts.

   <u>Noticed change</u>:

   (1) Not more than two (2) rafts; or two (2) lines; or one (1) raft and one (1) line may be used per permit.

   <u>No change alternative</u> *[original text moved from Section 164(j)(1)]:*

   (1) Not more than two (2) rafts and/or two (2) lines may be used per permit.

Finally, DFW has provided a detailed summary of and responses to individual comments received during the 45-day public comment period; for the reasons set forth in its responses to public comments, DFW does not believe the comments warrant changes to the regulations as proposed (Exhibit 11).

California Environmental Quality Act (CEQA)

A notice of exemption (Exhibit 13) has been drafted consistent with FGC staff's recommendation to rely on the statutory exemption in Fish and Game Code Section 7078(e), based on the assumption that the Herring FMP will be adopted as an environmental impact report-equivalent under Agenda Item 17 (this meeting), consistent with the Commission's Certified Regulatory Program. Pursuant to Fish and Game Code Section 7078(e), adopting regulations to implement an FMP or FMP amendment shall not trigger an additional review process under CEQA.

Significant Public Comments

1. Six commenters are opposed to the recreational daily bag limit as proposed and request a higher bag limit. Commenters state that take by recreational fishermen is minimal based on the amount of times spawning occurs; the majority of fishermen go once or twice a year, and a low number of between 30-50 fishermen participate (see exhibits 5 and 6). Commenter is not aware of recreational fishermen harvesting huge quantities of herring for illicit commercial trade as stated in the initial statement of reasons (Exhibit 10). Commenter has not seen scientific data indicating that recreational take has an impact on the fishery (Exhibit 8). Commenters recommend at least two 5-gallon buckets, or preferably four 5-gallon buckets (see Exhibit 9).

2. The Environmental Action Committee of West Marin recommends that the recreational take of roe should be prohibited in Tomales Bay, due to the sensitive nature of the eco-system and supports the Herring FMP's maximum daily bag limit of two 5-gallon buckets of Pacific herring (see Herring FMP Exhibit 17.7).

Recommendation

FGC staff: (1) Determine that a statutory exemption applies; and (2) Adopt the proposed regulations as recommended by DFW, unless FGC wishes to select a higher recreational take limit based on comments, in which case select within the 0-10 gallon range and adopt remaining regulations as recommended by DFW.

DFW: Adopt a recreational take limit of 5 gallons, adopt the regulations as proposed, except adopt the "No Change" Alternative for subsections 163.1(d) and 164(d).

Exhibits

1. DFW transmittal memo, received May 24, 2019
2. Initial statement of reasons
3. Staff summary for Agenda Item 26, Jun 12-13, 2019 FGC meeting (for background only)
4. Draft economic and fiscal impact statement (std. 399)
5. EML from Kirk Lombard, received Jul 24, 2019
6. EML from anonymous stakeholder, received Aug 7, 2019
7. EML from Ashley Eagle-Gibbs, Environmental Action Committee of West Marin, received Sep 26, 2019 (see Exhibit 17.7)
8. EML from Bradley Cain, received Jul 24, 2019
9. EML from Andrew Bland, received Jul 24, 2019
10. EML from John Vogel, received Jul 23, 2019
11. DFW memo and table with responses to public comments, received Oct 1, 2019
12. DFW presentation
13. Draft notice of exemption

Motion/Direction

Moved by _____________ and seconded by _____________ that the Commission determines, based on the record, that this approval is exempt from the California Environmental Quality Act as being subject to the statutory exemption in Fish and Game Code Section 7078(e) and adopts the proposed changes to Section 163 et al, related to the California Pacific Herring Fishery Management Plan implementing regulations with the "No Change" alternatives for subsections 163.1(d) and 164(d).

19. MALIBU OYSTER COMPANY STATE WATER BOTTOM LEASE – PUBLIC INTEREST

Today's Item **Information** ☐ **Action** ☒

Determine whether a new state water bottom lease applied for by Malibu Oyster Company offshore Malibu would be in the public interest.

Summary of Previous/Future Actions

- Receive new lease application — Jun 12-13, 2019; Redding
- **Today's potential public interest finding** — **Oct 9-10, 2019; Valley Center**
- Consider approving lease — TBD

Background

FGC has the authority to lease state water bottoms to any person for aquaculture (Section 15400, Fish and Game Code). Requirements for new lease applications and their consideration by FGC are specified in Section 15403 et seq. of the Fish and Game Code.

New Lease Application

At its Jun 2019 meeting, FGC received an application from J.P. Garofalo and Nick Mercer of Malibu Oyster Company (the applicant) to lease a new area covering 100 acres of state water bottom off the Malibu coast. As detailed in the lease application, the proposed lease area is located approximately one-half to one mile offshore from Malibu Pier in Malibu and its proposed siting was selected by the applicant to avoid commercial shipping lanes, marine protected areas, California halibut trawl grounds, areas of special biological significance, and leasable kelp beds, to avoid competing uses (Exhibit 1).

The potential lease site would be used to culture shellfish and certain seaweed species. The applicant proposes to culture seven species, of which the final four have not yet been commercially cultivated in California state waters: Pacific oyster, Olympia oyster, Kumamoto oyster, giant rock scallop, red sea urchin, giant kelp, and sugar kelp.

Public Interest Determination

Fish and Game Code sections 15400(a) and 15404 require that, prior to considering a new lease application, FGC must find that the lease area applied for is available (i.e., not otherwise leased or encumbered for other uses) and that the lease would be in the public interest.

To assist FGC in determining if the lease would be in the public interest, DFW has completed a review of the application, has consulted with the California State Lands Commission to determine that the area applied for is available, and has considered other potential uses for the area in its review. DFW's analysis and findings are provided in Exhibit 2.

Should FGC find that the lease would be in the public interest, staff will publish notice that FGC is considering the lease as prescribed in Fish and Game Code Section 15404, DFW will initiate tribal outreach and interagency coordination, and environmental review will be conducted by the applicant prior to final FGC consideration of the lease application and public input (Exhibit 2).

Significant Public Comments

1. A local restaurant seafood distributor submitted a letter in support of the applicant and its application for a state water bottom lease, citing that the applicant will increase opportunity for access to locally raised products for distribution (Exhibit 4).
2. A commenter expressed concern that the proposed lease area is sited within Malibu's swell corridor, which is listed in the National Register of Historic Places, and thus poses an incompatible use, is not in the public interest, and should not be considered in the proposed area. Commenter offers to work with the applicant to find an alternative location (Exhibit 4).

Recommendation

FGC staff: Approve DFW's recommendation and direct staff to ensure that concerns expressed over the siting of the lease area are explored through the CEQA and public review processes.

DFW: Based on the reasons identified within Exhibit 2, find that the area of the proposed new state water bottom lease for shellfish and seaweed aquaculture is available for leasing and that the lease would be in the public interest; and proceed with the next steps in public notice, tribal outreach, interagency coordination, and environmental review.

Exhibits

1. Malibu Oyster Company application for new lease, received Apr 22, 2019
2. DFW memo, received Sep 16, 2019
3. Email from Randy Lovell, transmitting comment letter dated Aug 2, 2019 from Michael King, King Seafood Company, as attachment, received Sep 10, 2019
4. Email from Michael Blum, Sea of Clouds, with attachment, received Sep 26, 2019

Motion/Direction

Moved by________________and seconded by ________________that the Commission finds the state water bottom lease area applied for by Malibu Oyster Company, for the purposes of shellfish and seaweed aquaculture, is available for lease, and that the lease would be in the public interest. Further, the Commission directs staff to initiate public notice pursuant to Section 15404 of the Fish and Game Code, and schedule for consideration the lease application following tribal outreach and interagency review, and environmental review conducted by the applicant.

OR

Moved by________________and seconded by ________________that the Commission finds the state water bottom lease area applied for by Malibu Oyster Company, for the purposes of shellfish and seaweed aquaculture, is available for lease but leasing the area is not in the public interest.

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20. ITEMS OF INTEREST FROM PREVIOUS MEETINGS (MARINE)

Today's Item **Information** ☒ **Action** ☐

This is a standing agenda item to provide FGC with updates on items of interest from previous meetings. For this meeting: Update on domoic acid levels in razor clams in Humboldt and Del Norte counties.

Summary of Previous/Future Actions

- Adopt emergency razor clam regulations — Apr 25, 2016; teleconference
- Update on domoic acid levels — Jun 22-23, 2016; Bakersfield
- Update on domoic acid levels — Aug 22-23, 2018; Fortuna
- **Today's update on domoic acid levels — Oct 9-10, 2019; Valley Center**

Background

This item is an opportunity for staff to provide any follow-up information on marine topics previously before FGC.

The recreational razor clam fishery has been closed since Apr 2016, when FGC adopted an emergency closure in Humboldt and Del Norte counties. The closure was in response to persistently high concentrations of domoic acid in clam meat and viscera, which led to a closure recommendation from the California Office of Environmental Health Hazard Assessment to protect human health.

Regular sampling has confirmed the continued persistence of high levels of domoic acid in razor clam meat in Del Norte and Humboldt counties. The most recent samples, taken from Clam Beach and Crescent Beach on Aug 3, 2019, indicate that concentrations have lowered overall; however, some samples remain above the alert level of 20 parts per million (Exhibit 1).

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. Email and sample results from Joe Christen, California Department of Public Health, received Sep 4, 2019

Motion/Direction (N/A)

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21. MARINE PETITIONS FOR REGULATION CHANGE

Today's Item **Information** ☐ **Action** ☒

This is a standing agenda item for FGC to act on regulation petitions from the public that are marine in nature. For this meeting:

(A) Action on the petition for regulation change received at the Aug 2019 meeting

(B) Pending regulation petitions referred to FGC staff and DFW for review – *none scheduled*

Summary of Previous/Future Actions

(A)

- Receive petition — Aug 7-8, 2019; Sacramento
- **Today's action on petition — Oct 9-10, 2019; Valley Center**

(B)

N/A

Background

Pursuant to Section 662, any request for FGC to adopt, amend, or repeal a regulation must be submitted on form FGC 1, "Petition to the California Fish and Game Commission for Regulation Change." Petitions received at an FGC meeting are scheduled for consideration at the next business meeting under (A), unless the petition is rejected under 10-day staff review as prescribed in subsection 662(b). A petition may be (1) denied, (2) granted, or (3) referred to committee, staff or DFW for further evaluation or information-gathering. Referred petitions are scheduled for action under (B) once the evaluation is completed and a recommendation made.

(A) ***Petitions for regulation change:*** One petition scheduled for consideration today was received at the Aug meeting; it was submitted by the comment deadline and published in the meeting binder.

Petition #2019-014: Increase restrictions on recreational take of California grunion (Exhibit A1).

(B) ***Pending regulation petitions:*** This is an opportunity for staff to provide a recommendation on petitions previously referred by FGC to staff, DFW, or a committee for review.

No pending regulation petitions are scheduled for action at this meeting.

Significant Public Comments (N/A)

Recommendation

FGC staff: Refer Petition #2019-014 to DFW for review and recommendation.

Exhibits

A1. Petition #2019-014, received Jun 20, 2019

Motion/Direction

Moved by _______________ and seconded by _______________ that the Commission adopts the staff recommendation to refer petition #2019-014 to the California Department of Fish and Wildlife for review and recommendation.

OR

Moved by __________ and seconded by __________ that the Commission adopts the following action for petition #2019-014: ______________________.

STAFF SUMMARY FOR OCTOBER 9-10, 2019

22. DEPARTMENT INFORMATIONAL ITEMS (MARINE)

Today's Item **Information** ☒ **Action** ☐

This is a standing agenda item to receive and discuss informational updates from DFW.

(A) Director's report

(B) Law Enforcement Division

(C) Marine Region

Summary of Previous/Future Actions (N/A)

Background

Verbal reports are expected at the meeting for items (A) through (C).

(A) The director's report will include items of interest since the last FGC meeting.

(B) Law Enforcement Division (LED) report: DFW's cannabis enforcement unit has worked with state, federal, and local partner agencies to remove illegal cannabis grows near sensitive wildlife habitat in Trinity and Shasta counties (See Agenda Item 12, Exhibit B1).

(C) The Marine Region report will include a video, *California Sea Cucumber Fishery: A Collaborative Project*, which showcases a DFW-fishing industry joint venture to support research and sustainable management of the fishery.

Also, decisions from the Pacific Fishery Management Council's Sep 13-18, 2019 meeting are provided to assist FGC in its continued tracking of council activities relevant to California (Exhibit C1).

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

C1. *Decision Summary Document – Pacific Fishery Management Council, Sep 13-18, 2019, dated Sep 23, 2019*

Motion/Direction (N/A)

STAFF SUMMARY FOR OCTOBER 9-10, 2019

EXECUTIVE SESSION

Today's Item **Information** ☐ **Action** ☒

Executive session will include four standing topics:

(A) Pending litigation to which FGC is a party
(B) Possible litigation involving FGC
(C) Staffing
(D) Deliberation and action on license and permit items

Summary of Previous/Future Actions (N/A)

Background

During the public portion of its meeting, FGC will call a recess and reconvene in a closed session pursuant to the authority of Government Code subsections 11126(a)(1), (c)(3), and (e)(1), and Section 309 of the Fish and Game Code. FGC will address four items in closed session:

(A) ***Pending litigation to which FGC is a party***

See agenda for a complete list of pending civil litigation to which FGC is a party.

(B) ***Possible litigation involving FGC***

None to report at the time the meeting binder was prepared.

(C) ***Staffing***

During a special FGC meeting on Sep 3, FGC selected Melissa Miller-Henson, its acting executive director, to fill the position of executive director. Ms. Miller-Henson formally assumed the position on Sep 10. For other details about staffing, see the executive director's report under Agenda Item 4(A) for today's meeting.

(D) ***Deliberation and action on license and permit items***

I. Consider Agency Case No. 19ALJ11-FGC, the appeal filed by Darren Johnson regarding DFW's denial of a request to renew a salmon vessel permit. DFW provided Mr. Johnson notice that his permit could not be reinstated in response to an untimely request to renew the permit (Exhibit D1). Mr. Johnson appealed that notice to FGC (Exhibit D2). DFW has responded stating that DFW does not object to the requested renewal (Exhibit D3). Note that if the appeal is granted, payment of pending fees is statutorily mandated.

Significant Public Comments (N/A)

Recommendation

(D) ***FGC staff:*** Grant the appeal filed by Mr. Johnson.

Exhibits

D1. Letter from DFW to Darren Johnson, dated May 31, 2019
D2. Letter from Darren Johnson to FGC, received Jul 23, 2019
D3. Letter from David Kiene of DFW's Office of General Counsel to FGC, received Sep 10, 2019

Motion/Direction

(D) Moved by ___________ and seconded by ___________ that the Commission grants the appeal by Darren Johnson regarding the Department's denial of a request to renew a salmon vessel permit.

CALIFORNIA FISH AND GAME COMMISSION PETITIONS
RECEIPT LIST FOR PETITIONS FOR REGULATION CHANGE: RECEIVED BY 5:00 PM ON SEPTEMBER 26, 2019
Revised 9/30/2019

General Petition Information					FGC Action	
Tracking No.	**Date Received**	**Name of Petitioner**	**Subject of Request**	**Short Description**	**FGC Receipt Scheduled**	**FGC Action Scheduled**
2019-019 AM 1	8/22/2019	Leif Orrell	Remove reticulated Gila monster from list of restricted species	Remove “reticulated Gila monster, (Heloderma suspectum),” from CCR 671 Title 14, restricted species list. Remove the phrase “This definition includes all specimens regardless of their origin even if they were produced in captivity” from the definition of Native Reptiles in Title 14. Remove the phrase “possess, purchase, propagate, sell, transport, import or export any native reptile or amphibian, or part thereof” from Title 14, Division 1, Subdivision 1, Chapter 5, CCR 40.	10/9-10/2019	12/11-12/2019
2019-020	8/21/2019	Justin Alvarez	Increase brown trout bag and posession limit	Within the Klamath Trinity River Basin, request that the bag limit and possession limit for recreational brown trout be raised to 10 and 20.	10/9-10/2019	12/11-12/2019

From: Leif Orrell [redacted]
Sent: Thursday, August 22, 2019 10:23 AM
To: FGC
Subject: Revised petition.
Attachments: FGC1.docx

FGC,
Attached is my revised petition of 21AUG19, I have noted updated authority for rule making and specified the requirement of receiving a response within ten days so that this petition may be given the adequate consideration I feel it deserves. Please feel free to contact me with any questions or concerns.

Leif Orrell
[redacted]
--
Leif Orrell

Tracking Number: (2019-019 AM 1)

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, 1416 Ninth Street, Suite 1320, Sacramento, CA 95814 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
   Name of primary contact person: Leif Landry Orrell
   Address: [redacted]
   Telephone number: [redacted]
   Email address: [redacted]

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: Authority cited: Sections 2118 and 2120, Fish and Game Code. Reference: Sections 1002, 2116, 2118, 2118.2, 2118.4, 2119, 2120, 2122, 2123, 2124, 2125, 2126, 2127, 2150, 2190 and 2271, Fish and Game Code.

3. **Overview (Required) -** Summarize the proposed changes to regulations: 1. Remove Heloderma Suspectum Suspectum "Reticulated Gila Monster" from CCR 671 Title 14, restricted species list 2. Remove the phrase "This definition includes all specimens regardless of their origin even if they were produced in captivity" from the definition of Native Reptiles in Title 14 3. Remove the phrase "possess, purchase, propagate, sell, transport, import or export any native reptile or amphibian, or part thereof" from Title 14, Division 1, Subdivision 1, Chapter 5, CCR 40.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: Heloderma Suspectum Suspectum is on the Restricted species list, CCR 671 Title 14. The rationale for this is "Those species listed because they pose a threat to native wildlife, the agriculture interests of the state or to public health or safety are termed "detrimental animals" and are designated by the letter "D". The department shall include the list of welfare and detrimental wild animals" Through my own research and the reading of research by others, the difference between the two Gila subspecies, H.S. Suspectum, and H.S. Cinctum, is negligible enough to be non-existent. These are essentially color morphs of the same species, which generally does not warrant enough for a definition of subspecies. The definition of this also limits the introduction of new genetic lines into *Cinctum's* range, as the interaction is interfered with by some geography. The two species' ranges do in fact overlap, but sparingly in some places due to human destruction of habitat and other factors. Further, the designation as a "Restricted

Species" implies danger either to the native *Cinctum* population from *Suspectum*, which is moot, or that *Suspectum* would somehow be more of a danger to humans than *Cinctum*, which is nonsense. The rationale for restricting one of these lizards is mooted by the fact that they interbreed regularly in overlapping ranges with no observable ill effects. Removing *Suspectum*, even if the subspecies are in fact separate, would allow responsible pet hobbyists to engage in meaningful study and education without impacting the native population of *Cinctum* because A. *Suspectum* and *Cinctum* are both widely cultivated in captivity, they would therefore avoid poaching risks or over collection of our native species. B. If they were to escape, there would be minimal impact on the native *Cinctum*, with *Suspectum* perhaps bolstering the genetic diversity of the species overall since their ranges currently overlap in many areas. C. Restricting BOTH subspecies so that they could not be kept as pets, even from captive bred populations as I propose, would not be of significant gain for the reasons listed above and they do not pose a significant threat to humans, or when interaction between the subspecies would occur. This would amount to restricting them from the pet trade "just to restrict something". Most descriptions and studies of the species do not even differentiate between the two subspecies when referring to range, color, temperament, diet, husbandry, or any other significant factors because the differences even on the genetic level seem to be nil. Restricting one or both of these species is disadvantageous to the honest pet and education trade because it is currently easier and less expensive to acquire a Gila outside the United States than it is to attempt to navigate the onerous permit process. Even in the unlikely event a permit were to be granted to an individual in the state of California, the process and regulations to obtain said permit is specifically prohibitive for hobbyists and those educators not part of an institution. Due to the species IUCN listing as "Least Concern" in conservation status, adopting the above suggestions will result in ethical study, education, enjoyment, preservation, and appreciation of a wonderful reptile that has been unavailable for the vast majority of Californians. SUBMITTED AS AMENDMENT 22AUG19 BY LEIF LANDRY ORRELL: I WAIVE MY RIGHT TO A RESPONSE WITHIN THE TEN DAY REQUIREMENT SPECIFIED BY THE COMISSION AND HAVE UPDATED THE RULEMAKING AUTHORITIES. I AM AVAILABLE FOR CONTACT BY PHONE DURING NORMAL WORKING HOURS.

SECTION II: Optional Information

5. Date of Petition: 12 Aug 19

6. Category of Proposed Change

☐ Sport Fishing
☐ Commercial Fishing
☐ Hunting
☒ Other, please specify: Restricted Species

7. The proposal is to: (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)

☒ Amend Title 14 Section(s):1.67, 40
☐ Add New Title 14 Section(s):
☒ Repeal Title 14 Section(s): 671

8. If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition

Or ☒ Not applicable.

9. **Effective date**: If applicable, identify the desired effective date of the regulation. If the proposed change requires immediate implementation, explain the nature of the emergency: January 1st, 2020

10. **Supporting documentation:** Identify and attach to the petition any information supporting the proposal including data, reports and other documents: References: https://www.heloderma.net/en/patterns.html, http://reptile-database.reptarium.cz/species?genus=Heloderma&species=suspectum, https://animals.sandiegozoo.org/animals/gila-monster,

11. **Economic or Fiscal Impacts:** Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing:

12. **Forms:** If applicable, list any forms to be created, amended or repealed:

SECTION 3: FGC Staff Only

Date received: Received by email on Thursday, August 22, 2019 at 10:23 AM.

FGC staff action:

☐ Accept - complete
☐ Reject - incomplete
☐ Reject - outside scope of FGC authority
Tracking Number

Date petitioner was notified of receipt of petition and pending action: _______________

Meeting date for FGC consideration: ___________________________

FGC action:

☐ Denied by FGC
☐ Denied - same as petition _____________________
Tracking Number
☐ Granted for consideration of regulation change

From: Justin Alvarez <jalvarez@hoopa-nsn.gov>
Sent: Wednesday, August 21, 2019 3:17 PM
To: FGC
Cc: Shaffer, Kevin@Wildlife
Subject: RE: FGC - Petition 2019-011
Attachments: FGC1_Brown Trout_v2.docx; brown trout letter.pdf; BrownTroutPlanLetterOfSupportUSFWS.pdf; Hoopa letter of support.pdf; Trinity Brown Trout Manuscript.pdf

Dear Commissioners,
I would like to withdraw my previous petition (2019-011) regarding changes to the Bag and Possession Limit for Brown Trout in the Klamath Basin and submit the attached petition.
Thank you,
Justin Alvarez

Justin Alvarez
Habitat Division Lead
Hoopa Tribal Fisheries
190 Loop Rd
Hoopa, CA 95546
Office # 530-625-4267x1020
Cell # 530-784-7883

Tracking Number: (2019-020)

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, 1416 Ninth Street, Suite 1320, Sacramento, CA 95814 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
Name of primary contact person: Justin Alvarez
Address: PO Box 417, Hoopa, CA 95546
Telephone number: (530)6254267
Email address: jalvarez@hoopa-nsn.gov

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: FGC1.2.1.205(b) & Sections 200, 202, 205, 210, 219 and 220, Fish and Game Code.

3. **Overview (Required) -** Summarize the proposed changes to regulations: We request that, within the Klamath Trinity River Basin, the bag limit and possession limit for recreational Brown Trout be raised to 10 and 20 respectively.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: Introduced Brown Trout pose an impediment to the recovery of the native fishes such as Chinook and Coho salmon, steelhead trout, and Pacific lamprey. These native species support both tribal and non-Indian fisheries. A recent predation study conducted by the Hoopa Valley Tribe and Humboldt State University found Brown Trout have the potential to consume large portions of the natural and hatchery production of anadromous salmonids. The NMFS specifically listed Trinity River Brown Trout as an impediment to recovery in its Southern Oregon Northern California Coastal Evolutionary Significant Unit (ESU) Coho recovery plan. The State of California increased the bag limit to 5 fish per day in 2007 because of predation concerns, and lists the following actions to deal with invasive species in their Coho Salmon recovery plan. Develop a rapid-response eradication plan for invasive, non-native fish species that negatively affect Coho Salmon. Develop management guidelines to mitigate the impacts of non-native fish species on Coho Salmon. Remove non-native fish species from stock ponds where these fish pose a threat to Coho salmon. In 2015, Brown Trout were estimated to have consumed 7% of the hatchery production and 20% of the natural production for that year. Given the large scale efforts on the

Trinity River to restore the native fishes we request the above actions be taken to ameliorate the negative impacts to the native fishes.

SECTION II: Optional Information

5. Date of Petition: August 21, 2019

6. Category of Proposed Change

☒ Sport Fishing
☐ Commercial Fishing
☐ Hunting
☐ Other, please specify:

7. The proposal is to: (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)

☒ Amend Title 14 Section(s):7.50(b)(91.1)(C)1a & 7.50(b)(91.1)(E)
☐ Add New Title 14 Section(s):
☐ Repeal Title 14 Section(s):

8. If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition

Or ☒ Not applicable.

9. Effective date: If applicable, identify the desired effective date of the regulation. If the proposed change requires immediate implementation, explain the nature of the emergency: Effective with release of 2020 supplemental regulations.

10. Supporting documentation: Identify and attach to the petition any information supporting the proposal including data, reports and other documents: Letter from Hoopa, Yurok, National Marine Fisheries Service, US Bureau of Reclamation, and Shasta Trinity Forest Service requesting action. Letter of support from Six Rivers Forest. Publication of Brown Trout Predation Study from Ecology of Freshwater Fishes. Letter of Support from US Fish and Wildlife Service. Mailed separately: Letter of Support from Trinity County Supervisors based on recommendation of the Trinity County Fish and Game Commission.

11. Economic or Fiscal Impacts: Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing: Benefits of Brown Trout Persisting: 1)provides an additional target species for recreational fishing 2)Potential increase in local revenue from fisherman targeting Brown Trout 3)Potential for increased fishing guide job opportunities Cost of Brown Trout Persisting; 1)Potential decrease in local revenue through negative impacts to the native fishery. 2)Loss of hatchery fish to Brown Trout Predation includes the cost of producing the hatchery fish and also lost fishing opportunities both recreational and commercial 3) Hampering recovery efforts for Chinook salmon and endangered Coho salmon

12. Forms: If applicable, list any forms to be created, amended or repealed:

Withdraw previous petition FGC1 Tracking Number: 2019-011.

SECTION 3: FGC Staff Only

Date received: Received by email on Wednesday, August 21, 2019 at 4:01 PM.

FGC staff action:

- ☐ Accept - complete
- ☐ Reject - incomplete
- ☐ Reject - outside scope of FGC authority

Tracking Number 2019-020

Date petitioner was notified of receipt of petition and pending action: ______________

Meeting date for FGC consideration: ___________________________

FGC action:

- ☐ Denied by FGC
- ☐ Denied - same as petition ____________________
  Tracking Number
- ☐ Granted for consideration of regulation change

Received by email on Wednesday, August 21, 2019 at 4:01 PM as a supporting letter to petition 2019-020

April 8, 2019

California Fish and Game Commission
1416 Ninth Street
Room 1320
Sacramento, CA 95814

Re: Trinity River Brown Trout Management Plan

Dear Commissioners:

On April 26th, 2018 a workshop was held to discuss the issue of Brown Trout management on the Trinity River. The workshop invited staff from all the resource management agencies: United States Fish and Wildlife Service (USFWS) California Department Fish & Wildlife (CDFW), Yurok Tribe, United States Forest Service (USFS), and National Marine Fisheries Service (NMFS), some invited stakeholder groups, and university staff. In the end, no stakeholder groups were able to attend, but all other parties were present. The outcome of this workshop was a list of management actions to recommend to the California State Fish and Game Commission

The purpose of this letter is to make recommendations on behalf of the Hoopa Valley Tribe (HVT), Yurok Tribe, USFWS, NMFS, USFS, and the USBR regarding management of Brown Trout within the Trinity River. Introduced Brown Trout pose an impediment to the recovery of the native fishes such as Chinook and Coho salmon, steelhead trout, and pacific lamprey. These native species support both tribal and non-Indian fisheries. A recent predation study conducted by the HVT and Humboldt State University found Brown Trout have the potential to consume large portions of the natural and hatchery production of anadromous salmonids. The NMFS specifically listed Trinity River Brown Trout as an impediment to recovery in its Southern Oregon Northern California Coastal Evolutionary Significant Unit (ESU) Coho recovery plan.
The state of California increased the bag limit to 5 fish per day in 2007 because of predation concerns, and lists the following actions to deal with invasive species in their Coho Salmon recovery plan.

- Develop a rapid-response eradication plan for invasive, non-native fish species that negatively affect Coho salmon.
- Develop management guidelines to mitigate the impacts of non-native fish species on Coho salmon.
- Remove non-native fish species from stock ponds where these fish pose a threat to Coho salmon.

In 2015, Brown Trout were estimated to have consumed 7% of the hatchery production and 20% of the natural production for that year. Given the large scale efforts on the Trinity River to restore the native fishes we request the following actions be taken to ameliorate the negative impacts to the native fishes.

We request that the bag limit and possession limit for recreational Brown Trout be raised to unlimited. This action would be unlikely to eliminate the population but would facilitate some suppression and would help raise awareness of the fact that Brown Trout are an invasive species.

We request that, as a condition of permitting studies on the Trinity River, all captured Brown Trout be removed from the water and euthanized. We are amenable to having these individuals donated to a food bank to eliminate wastage.

We request permission to conduct periodic electrofishing, targeting deep water areas in March to remove Brown Trout. The timing and location would minimize effects on other species and would be the most effective means of population suppression.

We request permission to pursue a bounty for Brown Trout to help suppression and as a way to garner buy in from fishing guides and the public.

In summary, we hope to work together to address this issue and develop a management plan for Brown Trout in the Trinity River. We believe that Brown Trout suppression is a positive step to improving the health of native fish populations as we continue to work toward delisting and preventing future listing of Klamath-Trinity River origin salmon, steelhead, and lamprey.

If you have questions or want to discuss further please feel free to contact Justin Alvarez of the Hoopa Tribal Fisheries Department at (530-625-4267 x 1020) or PO Box 417, Hoopa, CA 95546. He can answer or direct questions to any of the resource agencies as needed.

Sincerely,

Ryan Jackson,
Hoopa Valley Tribal Chairman

Joe James,
Yurok Tribal Chairman

Justin Ly,
North Coast Branch Supervisor
National Marine Fisheries Service

Mike Dixon, Ph.D.
Trinity River Restoration Program
U.S. Bureau of Reclamation

Scott Russell
Shasta Trinity Forest Supervisor
U.S. Forest Service

Received by email on Wednesday, August 21, 2019 at 4:01 PM as a supporting letter to petition 2019-020

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, California, 95521
Phone: (707) 822-7201 FAX: (707) 822-8411

August 14, 2019

Director Chuck H. Bonham
California Department of Fish and Wildlife
1416 Ninth Street, 12th Floor
Sacramento, California, 95814

Director Bonham:

This letter is in response to an August 7, 2019 formal request from the Hoopa Valley Tribe seeking the Service's support for the development and implementation of a Brown Trout Management Plan for the Trinity River by the California Department of Fish and Wildlife (CDFW).

The Trinity River is the focus of a large-scale river restoration project targeting recovery of anadromous fish populations to support the dependent ocean commercial, ocean and in-river sport, and in-river tribal commercial and subsistence fisheries. The U.S Fish and Wildlife Service's Fish and Aquatic Conservation (FAC) Program works closely with state, federal and tribal managers under a broad array of authorities such as the Fish and Wildlife Coordination Act to recover and restore endangered, threatened and imperiled aquatic species, fulfill tribal and public trust and mitigation responsibilities, and to restore and conserve a wide range of fish populations and other aquatic resources. To this end, the U.S Fish and Wildlife Service has been a long-time partner in the restoration of the Trinity River and recovery of its native species.

Brown Trout were introduced to the Trinity River, with a growing body of evidence that suggests they have been suppressing native species recovery efforts. Brown Trout opportunistically feed on other fishes, and their impact to native species has been well documented in rivers across the United States, including the Trinity River. According to a recent study led by the Hoopa Valley Tribe, Brown Trout consumed over 20% of the native wild salmonid biomass in the 40-mile reach of the Trinity River downstream of Lewiston Dam.

A workshop was held in Arcata in 2018 to discuss Brown Trout in the Trinity River. The workshop was hosted by the Hoopa Valley Tribe, and included representatives from a wide array of partners, including California Department of Fish and Wildlife, Yurok Tribe, U.S. Forest Service, Humboldt State University and U.S. Fish and Wildlife Service. The workshop culminated in a recommendation supporting the development of a CDFW management plan for Brown Trout in the Trinity River, with an emphasis on conservation and recovery of native species.

The Fish and Aquatic Conservation Program in the Arcata Fish and Wildlife Service Office is in full support of the development and implementation of a Brown Trout management plan, and we are willing to provide technical support and assistance to develop the plan, as requested by the Tribe.

Sincerely,

Dan Everson
Field Supervisor, Arcata Fish and Wildlife Office

Received by email on Wednesday, August 21, 2019 at 4:01 PM as a supporting letter to petition 2019-020

USDA United States Department of Agriculture
Forest Service
Pacific Southwest Region
Six Rivers National Forest
1330 Bayshore Way
Eureka, CA 95501
707-442-1721
TDD: 707-442-1721
Fax: 707-442-9242

File Code: 2630
Date: May 11, 2018

To Whom It May Concern,
The Six Rivers National Forest is a strong supporter of our local partners that contribute to our mission to restore and conserve our watersheds and local fisheries. We are concerned about invasive species (non-native species) whose introduction continues to cause economic and environmental harm. Brown trout (*Salmo trutta*) is one of those species that was introduced to the Trinity River in Northern California beginning in the 1890's. After in river planting stopped in 1932, Brown Trout have sustained their population without additional stocking. Today, there are numerous large scale efforts to restore the salmon and steelhead fisheries on the Trinity River and many of the Trinity River managers have been concerned that predation by piscivorous Brown Trout may impede efforts to restore native salmonids, in particular endangered Coho Salmon.

The National Marine Fisheries Service specifically listed Trinity River Brown Trout as an impediment to recovery in the Southern Oregon Northern California Coho recovery plan. The state of California increased the bag limit to 5 fish per day in 2007 because of predation concerns, and lists the following actions to deal with invasive species in their Coho Salmon recovery plan.

- Develop a rapid-response eradication plan for invasive, non-native fish species that negatively affect coho salmon,
- Develop management guidelines to mitigate the impacts of non-native fish species on coho salmon, and
- Remove non-native fish species from stock ponds where these fish pose a threat to coho salmon.

In 2015 and 2016, research studies were conducted by the Hoopa Tribe to quantify predation by Brown Trout on the native fishes of the Trinity River. They concluded a large portion of the hatchery and wild production was being consumed by Brown Trout. Armed with these findings, the Hoopa Tribe brought together managers and stakeholders to draft a Brown Trout Management Plan (2018). Some of the proposed recommendations outlined below are being considered at this time.

- Increase to no limit the Brown Trout Bag and Possession Limits,
- Cull Brown Trout at projects conducted on the Trinity when they are encountered,
- Engage in public outreach to encourage retention,
- Periodic electrofishing targeting Brown Trout, and
- Pursue a bounty for Brown Trout to help suppression and as a way to garner buy in from fishing guides and the public.

It is our responsibility as land stewards to stop the spread of this non-native fish species on public lands. These actions which have been identified prioritize recovery of the salmon and steelhead populations that support tribal, commercial, and recreational fisheries. We look forward to working with our partners on development of this plan and alternatives to remove Brown Trout throughout the Klamath Basin.

Sincerely,

MERV GEORGE JR.
Forest Supervisor

Received by email on Wednesday, August 21, 2019 at 4:01 PM as a supporting article to petition 2019-020
Received: 22 October 2018 | Revised: 8 January 2019 | Accepted: 12 February 2019
DOI: 10.1111/eff.12476

ORIGINAL ARTICLE

WILEY Ecology of FRESHWATER FISH

Predation on wild and hatchery salmon by non-native brown trout (*Salmo trutta*) in the Trinity River, California

Justin S. Alvarez[1] | **Darren M. Ward**[2]

[1]Fisheries Department, Hoopa Valley Tribe, Hoopa, California

[2]Department of Fisheries Biology, Humboldt State University, Arcata, California

Correspondence
Darren M. Ward, Department of Fisheries Biology, Humboldt State University, Arcata, CA.
Email: darren.ward@humboldt.edu

Funding information
Hoopa Valley Tribe Fisheries Department; National Oceanic and Atmospheric Administration, Grant/Award Number: CIMEC/Freshwater Fish Ecology RC

Abstract

Non-native predators may interfere with conservation efforts for native species. For example, fisheries managers have recently become concerned that non-native brown trout may impede efforts to restore native salmon and trout in California's Trinity River. However, the extent of brown trout predation on these species is unknown. We quantified brown trout predation on wild and hatchery-produced salmon and trout in the Trinity River in 2015. We first estimated the total biomass of prey consumed annually by brown trout using a bioenergetics model and measurements of brown trout growth and abundance over a 64-km study reach. Then, we used stable isotope analysis and gastric lavage to allocate total consumption to specific prey taxa. Although hatchery-produced fish are primarily released in the spring, hatchery fish accounted for most of the annual consumption by large, piscivorous brown trout (>40 cm long). In all, the 1579 (95% CI 1,279–1,878) brown trout >20 cm long in the study reach ate 5,930 kg (95% CI 3,800–8,805 kg) of hatchery fish in 2015. Brown trout predation on hatchery fish was ca. 7% of the total biomass released from the hatchery. Brown trout only ate 924 kg (95% CI 60–3,526 kg) of wild fish in 2015, but this was potentially a large proportion of wild salmon production because wild fish were relatively small. As large brown trout rely heavily on hatchery-produced fish, modifying hatchery practices to minimise predation may enhance survival of hatchery fish and potentially reduce the abundance of predatory brown trout.

1 | INTRODUCTION

Brown trout (*Salmo trutta*) have undergone massive range expansion from their native waters in Europe and North Africa to the waters of every continent except Antarctica (Dill & Cordone, 1997; MacCrimmon & Marshall, 1968). This expansion was intentional. European colonists transported and introduced brown trout around the world because they considered them desirable for sport fishing and food (Wilson, 1879). However, introduced brown trout may negatively affect populations of native fishes in areas where they have been introduced (Belk, Billman, Ellsworth, & McMillan, 2016; Hoxmeier & Dieterman, 2016; McHugh & Budy, 2006; Townsend, 1996). In this study, we evaluated predation by introduced brown trout on native salmon and trout species that are the focus of a large-scale, intensive conservation and habitat restoration effort in the Trinity River, a large tributary of the Klamath River in Northern California.

In Northern California, Scottish, German and hybrid brown trout eggs were brought to Fort Gaston (Hoopa, CA) and Sisson hatcheries near Mt. Shasta by train in the 1890s (Adkins, 2007; Thomas, 1981). There were two introductions from those hatcheries to the Trinity River, one near the mouth at Fort Gaston and a separate effort closer to the headwaters in Stewart's Fork and the main stem Trinity River near Lewiston, CA (Adkins, 2007; Thomas, 1981). According to a Trinity Journal newspaper article (1911), the motivation behind the upstream introduction was the California Fish and Game Commission's plan to replace native rainbow trout (*Oncorhynchus mykiss)* with the “more desirable brown trout” throughout the state.

The downstream introduction was implemented to supplement the dwindling salmon fishery that the local Hoopa Tribe relies on for sustenance (Adkins, 2007). In the early years of brown trout introduction to the Trinity River, fisheries managers raised concerns that the brown trout predation was impacting abundance of native salmon species through predation (Thomas, 1981). This lead to a moratorium on brown trout releases in the Trinity River during the 1920s, but the moratorium was short lived and brown trout stocking was gradually phased back in and continued until 1932 (Thomas, 1981).

Prior to and during the time period when brown trout were introduced, native fishes of the Trinity River experienced steep declines in abundance (Adkins, 2007). Native and tribally-important species such as Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), steelhead trout (*O. mykiss*) and Pacific lamprey (*Entosphenus tridentatus*) were affected by large-scale habitat loss from intensive mining and logging throughout the watershed. A pair of dams completed in the early 1960s exacerbated these effects, cutting off access to the entire upper watershed for migratory fish and diverting a substantial fraction of the Trinity River's water to California's Central Valley for irrigation. The Trinity River hatchery was completed in 1958 to partially mitigate the effects of habitat loss on salmon production. The hatchery currently releases more than 2 million juvenile salmon and steelhead per year into the Trinity River and spawns returning adults to produce the next generation of hatchery fish (California Hatchery Scientific Review Group, 2012). Recent efforts to rehabilitate the native fish populations of the Trinity River also include a massive investment in habitat restoration, including large-scale channel reconfiguration, cover addition, minimum flows, and habitat-forming flow releases from the dams (Beechie et al., 2015). Currently, Trinity River Chinook salmon and steelhead remain well below historic abundance and Trinity River coho salmon are considered threatened under both state and federal laws (National Marine Fisheries Service, 2014).

The potential for brown trout to directly affect native salmon populations by predation depends on brown trout feeding behaviour and abundance. Piscivory by Trinity River brown trout has been documented during field projects focused on other species and by local fisherman, but no formal diet studies of this brown trout population have been conducted. The best historical index for brown trout abundance in the Trinity River is the adult salmon sampling weir in Junction City (river kilometre 136.2). Brown trout catch totals increased at the weir during sampling from 2000 to 2013 to levels 200%–300% higher than those in the 1980s and 1990s, despite reduced sampling effort since 2000 (Borok, Cannata, Hileman, Hill, & Kier, 2014; Borok, Cannata, Hill, Hileman, & Kier, 2014; National Marine Fisheries Service, 2014). Documentation of piscivory combined with the potential increase in brown trout populations inferred from weir catch data suggests that brown trout may be having a substantial impact on native fishes. This threat was identified by the California Department of Fish and Wildlife in 2005 and provided the impetus for changing fishing regulations, adding a bag limit of one brown trout in 2006 and increasing it to five brown trout in 2007 (California Fish & Game Commission, 2007). Trinity River brown trout were also identified as an impediment to species recovery in the recovery plan for Southern Oregon and Northern California coho salmon (National Marine Fisheries Service, 2014).

To assess predation by brown trout on native species, we undertook the first large-scale sampling effort for brown trout in the Trinity River. Sampling included multi-pass electrofishing over a 64-km study reach to estimate abundance, size, growth and age structure of brown trout. We used diet sampling and isotope analysis to characterise brown trout diet composition. Finally, we used the brown trout population and diet data to parameterise a bioenergetics model to estimate brown trout consumption of salmon and other prey in the Trinity River.

2 | METHODS

2.1 | Study area

The Trinity River in Northern California is the largest tributary to the Klamath River, with a main stem length of 274 km and a watershed area of about 7,679 km^2. The Trinity River's headwaters are in the Trinity Alps at an elevation of about 1,850 m, and the confluence with the Klamath River in Weitchpec is 69.5 km from the ocean at an elevation of 56 m. There are two large earthen dams on the Trinity River. Upstream at river kilometre 261.6 is Trinity Dam, which is used for water storage, and downstream at river kilometre 250.3 is Lewiston Dam, which is used to export water to the Sacramento River basin. The Trinity River Fish hatchery is located at Lewiston Dam, and all hatchery-produced fish are released immediately downstream of the dam.

This study is focused on the 64 km of the main stem Trinity River below Lewiston Dam and above the North Fork of the Trinity River (Figure 1). Existing observations indicate that brown trout are widespread through the 178 km of anadromous habitat in the main stem Trinity River as well as major tributaries. However, based on habitat use data collected for other studies (Goodman, Som, Alvarez, & Martin, 2015), brown trout are most abundant in the focal area and it is the area where they likely have the most access to native salmon prey from hatchery releases and natural spawning grounds.

Discharge from Lewiston Dam ranges annually from 8.6 to 311.5 m^3/s. With tributary inputs downstream of the dam, the Trinity River near the North Fork experiences flows between 12 and 850 m^3/s. There is a characteristic seasonal flow pattern: during winter and spring storms and an annual spring dam release, the upper range is approached; by mid-summer and through winter the flows stay closer to the lower range.

The 64 river kilometres in which the study took place were divided into six reaches based on tributary inputs, river access and prior information about brown trout density (Figure 1). The boundaries of each reach occurred at the following locations and creek mouths in downstream order: the concrete weir below Lewiston Dam, Rush Creek, Steel Bridge river access, Indian Creek, Evans Bar river access, Canyon Creek and the North Fork of the Trinity River.

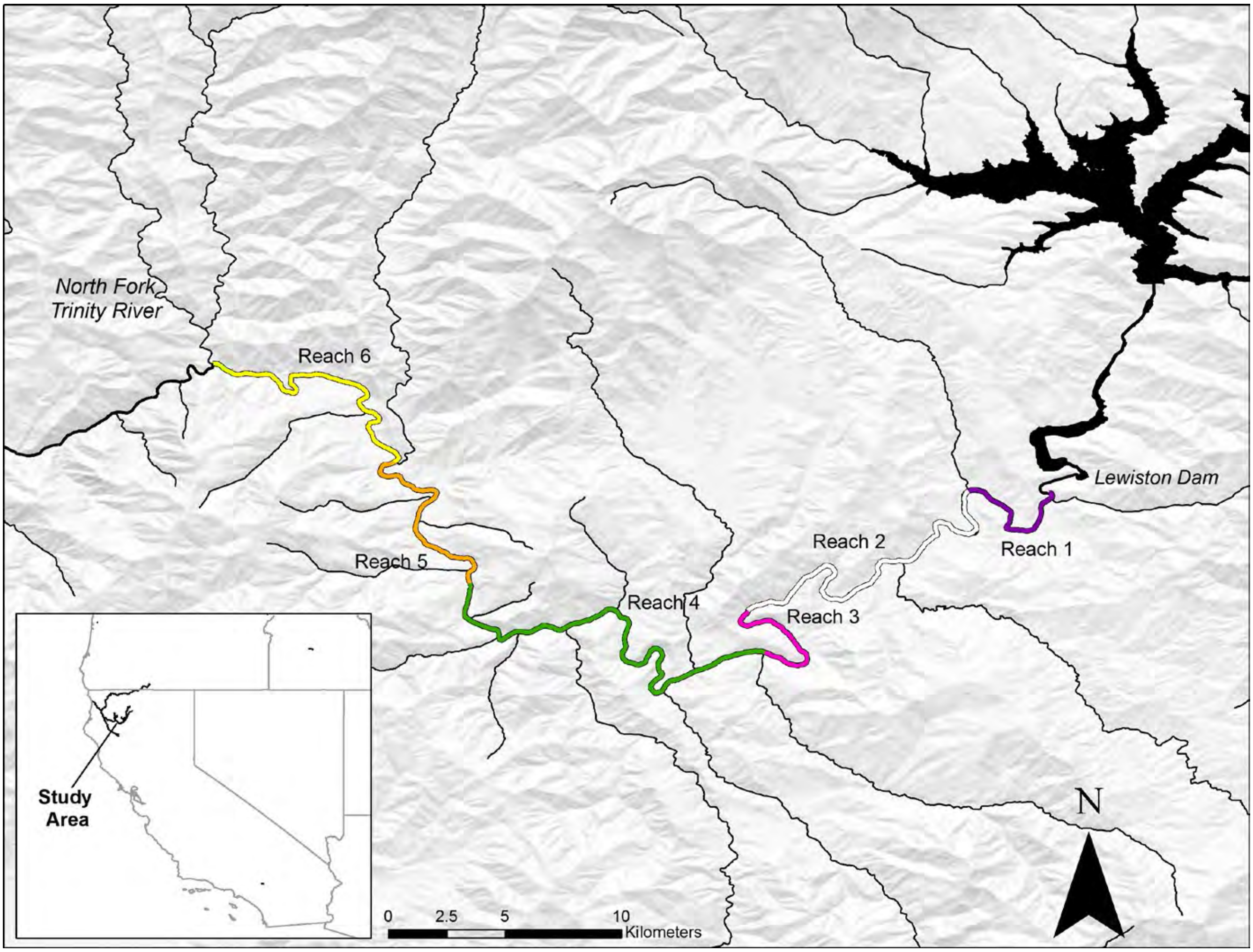

FIGURE 1 Map of the study area with an inset regional map of California. The Trinity River flows from right to left. The study area begins at Lewiston Dam and ends at the confluence of the main stem with the North Fork of the Trinity River. Within the study area, each reach is highlighted with the colour of the Floy T-bar tag that was used to mark fish, matching the temperature profile lines in Figure 2

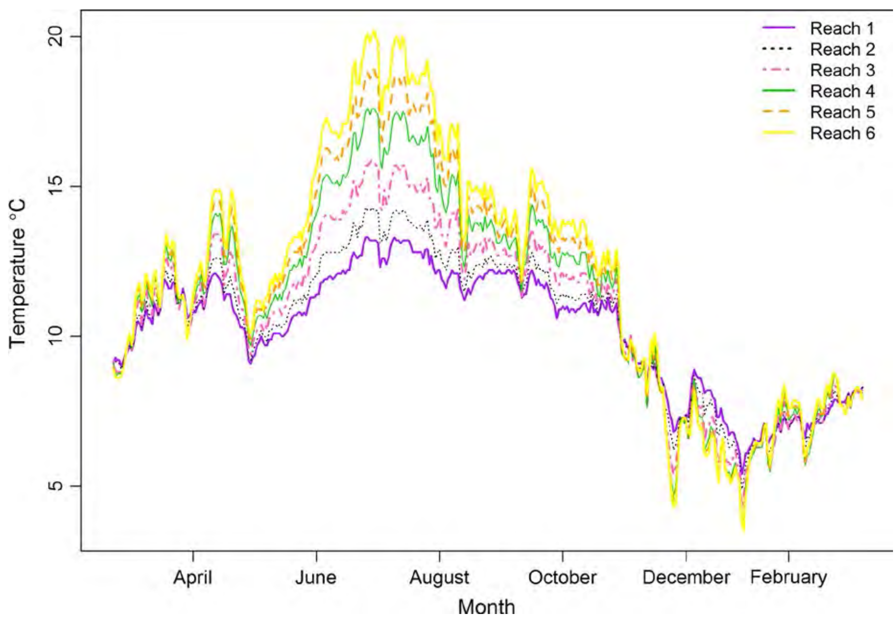

FIGURE 2 Temperature profiles of each reach where Reach 1 is the furthest upstream and Reach 6 is the furthest downstream. The colour of the line matches the colour of the reach in Figure 1

2.2 | Fish sampling

A 4.3-m raft with a Smith-Root 2.5 kW generator powered pulsator electrofisher system (Smith-Root Inc., Vancouver, WA) was used to sample the entire 64 km of river. The control box was set with a DC pulse rate of 30 Hz with voltage between 300 and 400. Sampling focused on the thalweg of the main stem while moving slowly downstream. In March of 2015, the study area was sampled with three passes. Each pass proceeded from upstream to down and took 4 days to complete. A single sampling pass started near Lewiston Dam on Monday and worked down to a river access. Tuesday sampling began where Monday's sampling left off and this pattern continued until the 64 km was completed on Thursday. The following Monday, a new pass would begin starting at Lewiston Dam again. The 7-day interval between samples at a given location allowed brown trout to recover from handling stress and resume normal feeding behaviour before being resampled (Pickering, Pottinger, & Christie, 1982). The three passes bounded the spring release of coho salmon smolts from the hatchery: the first pass was completed before the release, the second immediately following the release, and the third after many of the released smolts had migrated through the study area (Harris, Petros, & Pinnix, 2016). A similar brown trout sampling effort was conducted in the spring of 2016, providing additional diet samples and recaptures for final growth measurements of tagged individuals.

Most brown trout were sampled by electrofishing (859 total), but additional samples were collected opportunistically by other means to provide diet data from outside the spring electrofishing season and to provide additional samples for size and growth analyses. An Alaskan style weir, operated by the California Department of Fish and Wildlife and the Hoopa Tribe, was installed in Junction City California in late June and run through September in 2015 and 2016 to catch migrating adult salmon (Sinnen, Currier, Knechtle, & Borok, 2005). Brown trout captured in the weir in 2015 and 2016 (224 total) were processed as described below. We also processed some additional individuals captured using rod and reel (29 total). All methods produced a similar size range of fish, from 20 cm (minimum size used in the analysis) to at least 60 cm.

2.3 | Processing and handling

Once captured, all brown trout >20 cm long were anaesthetised in water saturated with CO_2 using Alka-Seltzer Gold tablets. Trinity River brown trout are the target of a recreational fishery, so alternative anaesthetics that require a withdrawal period before human consumption were not suitable for this work. Fish <20 cm long were too small for our tagging operation and were less likely to be piscivorous, so we did not include smaller fish in subsequent analysis. Once anaesthetised, the fish were measured (fork length) and the following samples were collected: scales were taken from the left side between the anal and dorsal fin just above the lateral line for age analysis, a 1 cm^2 fin clip was taken from the distal posterior tip of the dorsal fin for stable isotope analysis, and stomach contents were collected using gastric lavage for diet analysis. Fish were weighed following gastric lavage so that stomach contents would not contribute to the mass. Lavage was conducted using a hand-pumped garden sprayer. The spray pipe was placed through the fish's mouth into the stomach and water was sprayed in until the stomach was full. Through continued filling and massaging the belly from the outside, food items were washed and pushed out. A subsample of 30 fish was sacrificed after processing and the stomachs examined to gauge the effectiveness of the gastric lavage. Of these, 28 had completely empty guts, indicating that lavage was generally effective.

After the samples and measurements were taken, the fish were tagged with a uniquely numbered FD94 T-bar tag (Floy Tag & Manufacturing Inc., Seattle, WA) for future identification and then released. The tags were made of a 7.5-cm-long piece of monofilament with polyolefin coloured tubing around it. At the insertion, end was a 1.5-mm-thick, 2-cm-wide "T." The tag was injected using Floy Tag's Mark III pistol grip tagging gun. The needle was inserted below the dorsal fin to allow the T to articulate with the dorsal support skeleton. The colour of the T-bar tag corresponded with a reach (Figure 1) where the fish was collected. These colours allowed a quick visual indication of larger-scale movements while sampling fish in the field and were a check for the closure assumption of the population estimate. Fish captured at the weir received a Floy tag with a distinct tag colour to differentiate them from fish tagged during electrofishing.

2.4 | Analysis

2.4.1 | Population estimate

The electrofishing passes were used to generate the population estimate used in the energetics simulation (described below). The population estimate was calculated using Chapman's estimator (Seber, 1982). This estimator assumes a closed population, with no births, deaths, emigration or immigration. Movement assumptions were tested using the different coloured tags in each reach. During the three-pass sample bout, all but one of the recaptured fish were found in the reach where they were initially tagged. Based on the lack of individual movement and the short timeframe for births and deaths in the 1 week between passes, we considered the closure assumptions met. The first pass was used as the first sampling occasion while the second and third passes were combined into a second sampling occasion.

Not all of the reaches had enough recaptures of tagged fish to calculate a separate population estimate for each reach with reasonable precision, so the whole surveyed section of river was treated as one population for the main estimate. Subsequently, we calculated a population estimate for each reach by dividing the main population estimate among reaches proportionally to the catch in each reach. Using this approach, the overall population estimate used the maximum sample size available.

2.4.2 | Age and growth analysis

Brown trout scales were sorted, mounted and examined following the plastic impression method (Clutter & Whitesel, 1956; Van

Alen, 1982). After discarding unreadable or regenerated scales, each scale was assigned an age and a confidence level (high, medium or low); those scales with a low confidence level were not used in subsequent analyses. To ensure age readings were being performed consistently, scales taken from individual fish that were sampled in multiple years were checked to ensure the increase in age estimates from the scales matched the time that passed between sampling. These checks were conducted blind to the original data by the same reader. All repeat-sampled fish (n = 31) were aged consistently.

The length and age data were fit to a von Bertalanffy growth model assuming additive error with normally distributed residuals using the nonlinear least squares (nls) function in base R (R Development Core Team, 2009). The model is as follows: $L_t = L_\infty \left(1 - e^{-k(t-t_0)}\right) + \varepsilon$ where L_t is fork length at age t, L_∞ is the asymptotic maximum length, k defines the rate at which the asymptote is approached, t_0 is the hypothetical age of the fish at size zero, and ε is error.

We also fit individual length and mass measurements to an allometric curve with multiplicative error in base R (R Development Core Team, 2009) using the nls function. This relationship was used in the bioenergetics model to convert the predicted growth in length from the von Bertalanffy model to growth in mass for the bioenergetics model.

2.4.3 | Annual survival analysis

Age-frequency data can be analysed in multiple ways to estimate survival rates. In simulation studies, the Chapman–Robson survival estimate had less bias and less error than other techniques, especially at small sample sizes (Dunn, Francis, & Doonan, 2002), so that method was applied. The Chapman–Robson estimator is formulated as follows:

$$\hat{S} = \frac{T}{n + T - 1}$$

where $T = \sum (x \times N_x)$, where $\hat{S}$ is the annual survival estimate, n is the total number of aged fish from the fully recruited ages, x is the coded age where coded age 0 is the age with the highest number of individuals caught, and N_x is the number of individuals of each age. This approach assumes constant survival throughout the population and constant recruitment across years. We calculated separate survival estimates for the 2015 and 2016 catch and used the average of the two for the consumption model.

2.4.4 | Isotope analysis of diet composition

We measured carbon and nitrogen isotope ratios in 253 brown trout fin clip tissue samples as well as in samples of multiple potential prey items. We selected prey items to analyse for isotopes based on the prey that were most prevalent in the gut samples. Prey items included various mayflies (Ephemeroptera), golden stoneflies (Perlidae) and salmonflies (*Pteronarcys californica*), as well as lamprey ammocoetes, wild steelhead trout fry and hatchery coho salmon smolts. As juvenile salmonids of different species generally have similar diets, we assumed that wild steelhead fry represented the isotope composition of wild salmon and trout (including potential cannibalism on juvenile brown trout). All hatchery fish are fed the same food, based on marine-derived fish meal, so we assumed that the hatchery coho salmon smolts represented the isotope composition of all hatchery species. Nonsalmonid fish species besides lamprey were rare in the diet samples (present in <1% of samples), so they were not assessed as potential prey in the isotope analysis. The prey samples were collected from a rotary screw trap run by the Hoopa Tribal Fisheries programme that is located within the sample area in the downstream reach. Isotope samples were placed on ice immediately after collection and were transferred to a freezer upon return from the field at the end of the day. From the freezer, the samples were transferred to a drying oven set to 65°C and were dried for 36–60 hr. The dried samples were homogenised, and a subsample of 0.5–1.5 mg removed, weighed and placed into a tin capsule. The encapsulated tissue was placed in a plastic tray in one of 96 wells.

The filled trays were sent to UC Davis stable isotope laboratory for analysis of Carbon 13 (δ^{13}C) and Nitrogen 15 (δ^{15}N) using a PDZ Europa ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20–20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire, UK). The δ^{15}N and δ^{13}C values reported were the values of the sample relative to ratios of the international standard for each element, air for nitrogen and Vienna PeeDee Belemnite for carbon.

Isotopic data were used to determine the proportion of each prey type within the diets of the brown trout. Prey were grouped into four categories: ammocoetes, aquatic invertebrates, hatchery salmonids and wild salmonids. Limiting the ratio of prey groupings to isotopes improves model fit (Phillips & Gregg, 2003). As brown trout length was found to be positively correlated with δ^{15}N and δ^{13}C (r^2 of 0.55 and 0.58 respectively), the brown trout isotope data were grouped into five categories based on fork length: <30, 30–40, 40–50, 50–60 and >60 cm. These break points provided adequate samples within each bin to facilitate isotopic analysis and improved resolution within the bioenergetics model when converting food requirements to biomass consumed. The proportions of each prey type consumed by each brown trout group were estimated by fitting the isotope data using a Bayesian framework in the R package MixSIAR (Stock & Semmens, 2013). This package uses a Markov Chain Monte Carlo (MCMC) approach to fitting multi-linear models. Three chains were run with one million iterations each. The burn in length was 500,000, and the thinning rate was 500. The model was run with brown trout size category as a fixed effect and only residual error. Estimated fractionation rates were derived by averaging values from literature sources: 3.74 *SD* 0.477 for δ^{15}N and 1.38 *SD* 0.983 δ^{13}C (Flinders, 2012; McCutchan, Lewis, Kendall, & McGrath, 2003; Minagawa & Wada, 1984; Peterson & Howarth, 1987; Vander Zanden, Cabana, & Rasmussen, 1997; Vander Zanden & Rasmussen, 2001).

2.4.5 | Bioenergetics

A bioenergetics approach was used to estimate total prey consumption by brown trout, with a parametric bootstrap to characterise the variance of the estimate. The bioenergetics simulation represented

TABLE 1 Parameters of the Wisconsin bioenergetics model and the values used to implement it

Parameter	Value	Parameter definition
CTO	17.5	Water temp corresponding to 0.98 of the maximum consumption rate
CTM	17.5	The upper end of the temperature where still at 0.98 of the maximum consumption rate
CQ	3.8	Water temperature at which temperature dependence is a fraction (CK1) of the maximum rate
CA	0.2161	Intercept of mass dependence function for a 1-g fish at optimum water temperature
CB	−0.233	Coefficient of mass dependence for increasing portion of curve
CTL	20.8	Temperature at which consumption is reduced some fraction (CK4) of the maximum rate
CK1	0.23	Specific rate of respiration (g g^{-1} d^{-1})
CK4	0.1	See CTL
RA	0.0113	Intercept for the allometric mass function for respiration
RB	−0.269	Slope of allometric mass function for respiration
RQ	0.0938	Approximates the rate at which the function increases over relatively low water temperature
RK1	1	Intercept for swimming speed above the cut-off temperature
RK4	0.13	Mass dependent coefficient for swimming speed at all water temperatures
BACT	0.0405	Water temperature dependent coefficient of swimming speed at water temp below RTL
RTO	0.0234	Coefficient for swimming speed dependence on metabolism (s/cm)
RTL	25	Cut-off temperature at which activity relationship changes
ACT	9.7	Intercept of the relationship between swimming speed and mass at a given temperature
LOSS	0.35	Energy lost to faeces and specific dynamic action
EDA	6,582	Intercept for energy density–weight function
EDB	1.1246	Slope of the energy density–weight function

Note. The model equations and parameter meanings are described in Hansen et al. (1997). All parameter values are from Dieterman, Thorn, and Anderson (2004) except LOSS, which is from Burke and Rice (2002).

the growth and consumption of age 2–12 brown trout over 1 year. The model ran on a daily time step where 1 March 2015 was model day one. The base of the simulation was the Wisconsin Bioenergetics model (Hansen, Johnson, Kitchell, & Schindler, 1997) coded into R (code by Andre Buchheister, personal communication, August 2015). Published values for parameters relating to brown trout metabolism, egestion, activity, growth and consumption were used to set a baseline and facilitate comparison to other studies (Table 1). We did not have information about brown trout spawning frequency in the system, so we did not include gamete loss in our model, potentially producing an underestimate of total consumption.

To estimate the maximum amount a brown trout could consume, we used Hansen et al.'s (1997) third consumption equation, as it is designed for cold water fishes such as brown trout. In the model, consumption is dependent on size, water temperature and the amount of food consumed in laboratory experiments during ad libitum feeding at optimal temperatures. To estimate what brown trout actually consume, the modelled maximum consumption is scaled by the proportion of maximum consumption (p). The proportion of maximum consumption was allowed to vary between simulation iterations to achieve the targeted growth of the brown trout of each age. Parameters representing the mass at the start of the year, mass-specific growth rate, population size, survival rate and diet composition were randomly selected for each iteration of the model from a normal distribution, with a mean and standard deviation for each parameter derived from the field data (Table 2).

Additional input data required to estimate consumption included mean daily temperature and prey-specific energy density. The temperature fish experienced was determined using linear interpolation of the mean daily temperature between available U.S Geological Survey gage stations (ID numbers 11525500, 11525655, 11525854 and 11526400). The temperature profiles used in the energetics model were that of the midpoint of each reach from 1 March 2015 through 28 February 2016 (Figure 2). The prey energy densities were literature values: invertebrates 4.07 kJ/g (Groot, Margolis, & Clarke, 1995; Myrvold & Kennedy, 2015), lamprey ammocoetes 3.54 kJ/g (Alvarez, 2017), other fish 5.78 kJ/g (Hansen et al., 1997). Temperature and prey energy density were not randomised as part of the bootstrap.

Each simulation started with a random draw of average starting size for brown trout of each age from 2 to 12 (Table 2). Then, randomly drawn von Bertalanffy parameters were used to calculate average sizes at the end of the year. After converting length to mass, an optimisation function optim in R (R Development Core Team, 2009) was used to find the proportion of maximum consumption required to achieve the selected final mass within each reach for an individual of each age. During that growth interval, daily size and consumption were recorded for each fish. Next, a random draw of population size and survival rate was used to find the number of fish of each age on each day. Finally, the number of fish alive on each day within the appropriate reach and of the appropriate age was used to expand the individual brown trout daily consumption estimates to the reach level. To facilitate allocating total consumption to different prey types, the total biomass consumed each day was aggregated into the five length-based bins used in the stable isotope mixing model. This process was repeated 3,000 times to characterise the variation in consumption

TABLE 2 Brown trout population parameters for the bioenergetics simulation

Parameter	Mean	Standard error
Population size		
Reach 1	111	65.5
Reach 2	300	178.5
Reach 3	95	56.5
Reach 4	553	328.5
Reach 5	284	169
Reach 6	237	141
Annual survival	58.3%	2.4%
Initial size (cm)		
Age 2	20.0	2.4
Age 3	34.0	4.7
Age 4	40.6	4.0
Age 5	47.0	4.5
Age 6	53.2	4.7
Age 7	56.6	5.1
Age 8	62.8	5.2
Age 9	66.0	4.9
Age 10	69.0	4.9
Age 11	72.0	4.6
Age 12	75.0	4.6
Growth rate		
L_∞	90.6	2.9
K	0.14	0.009
t_o	−0.21	0.055

Note. The estimates and variance are derived from field data collected during this study.

given different growth rates, and to account for the error associated with growth, abundance and survival estimates. The error estimate does not include variation associated with process error or bioenergetics parameters taken from the literature. These model runs produce estimates of the total biomass of food with the energy density of brown trout that is consumed for each size class.

Diet proportion, predator and prey energy densities, and the estimate of consumption from the simulation were combined to find the biomass of each prey category consumed by brown trout. For this portion of the analysis, the posterior distribution from the isotopic analysis was treated as a parametric bootstrap which we drew from with a multinomial random draw. A random multinomial draw of consumption by for each size bin was combined with a draw of prey proportion and energy densities in the equation = $\frac{E}{A\times E_A+H\times E_H+W\times E_W+I\times E_I}$, where B is the total biomass consumed and E is the total energy required. The symbols A, H, W and I are the proportion ammocoetes, hatchery fish, wild fish and invertebrates contribute to total biomass consumed respectively. E_x is the energy density of the prey category x. The resulting biomass combined with the random draw of proportions provides the biomass of each prey type consumed by the population for a single iteration. This process was repeated 100,000 times to generate a distribution of consumption estimates, ensuring multiple combinations of the consumption and diet composition estimates.

3 | RESULTS

In 2015, we captured 589 brown trout between 20 and 79 cm. Based on recaptures, we estimated the population to be 1580 (95% CI 1,279–1,878). The scale samples collected from these fish revealed

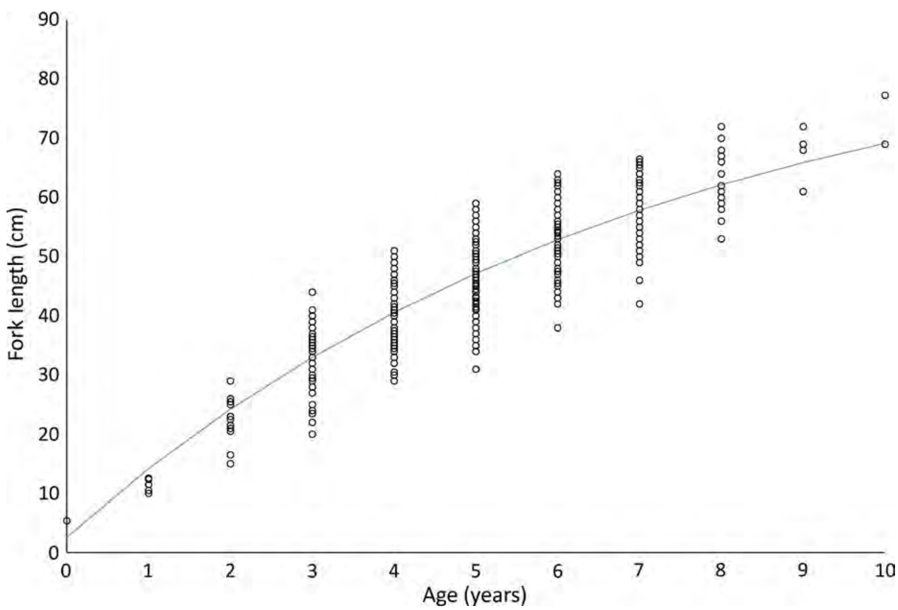

FIGURE 3 Age and size for all individual brown trout and the fitted Von Bertalanffy growth curve. Von Bertalanffy parameter estimates and standard errors are in Table 3

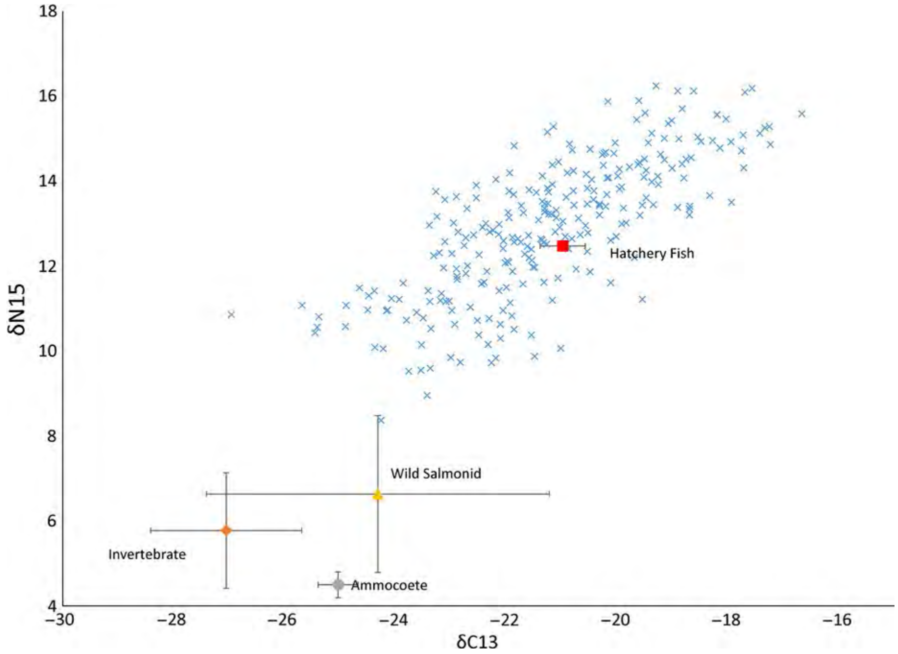

FIGURE 4 Isoplot of brown trout and prey items. Blue x's represent individual brown trout isotope ratios. Prey items are labelled and the location is the mean value for that prey category. The error bars are a single standard deviation

their ages ranged from 2 to 11 years (Figure 3). This sample provided sufficient representation of the population's age and size composition to estimate growth and survival parameters for the bioenergetics model (Table 2).

Wild fish and invertebrate prey had lower δ^{15}N and δ^{13}C than hatchery fish. Brown trout isotope values ranged from in between wild prey and hatchery fish values to higher than both (Figure 4). The MixSIAR model MCMC chains converged with all parameters having $\hat{R}$ values of >1.01 $\hat{R}$ < 1.05 is acceptable for inference (Stock & Semmens, 2013). The model results show that the large brown trout consume very a high proportion of fish, especially hatchery fish, and that reliance on fish declines in smaller brown trout (Figure 5). A relatively small proportion of the diet comes from wild fish.

The snapshot of diets from gastric lavage samples shows a similar level of piscivory as the isotope model for larger size classes, but lower than the isotope model for small size classes (Table 3). However, gastric lavage lacks the full temporal scale of the isotope analysis and is not as effective at parsing out wild and hatchery fish. While most fish retrieved during lavage were not identifiable to hatchery or wild origin (based on hatchery marking), the temporal pattern of fish consumption by brown trout was consistent with heavy reliance on hatchery-released fish. The number of fish found in stomachs of brown trout peaked in the sample pass conducted immediately following the release of coho salmon smolts from the hatchery (average: 2.2 fish per stomach; *SD* 2.6; range: 0–11) relative to the sample before the smolts were released (average: 0.3 fish per stomach; *SD* 0.8; range: 0–9) and after most hatchery coho salmon smolts had moved out of the study area (average: 0.3 fish per stomach; *SD* 0.7; range: 0–2). Across all samples, coho salmon were the most common identifiable fish in lavage samples (n = 36), followed by steelhead (n = 16), Chinook salmon (n = 5) and brown trout (n = 5, not counting one individual that apparently consumed four small brown trout in the live well during sampling). Additional fish recovered from lavage samples were not identifiable to a single species, but based on size and time of year we could narrow these fish to the two most likely prey species: larger fish were either yearling coho salmon or steelhead trout (n = 73) and the smaller fish were either Chinook or coho salmon (n = 14).

The energetics simulation predicted that the brown trout population needed to consume 58,382 megajoules (95% CI 39,334–77,432) of energy per year. Variation in growth rate accounted for most of the dispersion around the consumption estimates. The variation around the population size and survival rate estimates added additional variation around the consumption estimate, but this variation was almost inconsequential when compared to differences from growth. When energy was converted into prey biomass by category, the most-consumed prey item was hatchery fish, followed by invertebrates, wild fish and ammocoetes (Figure 6). In 2015, brown trout consumed 5,930 kg (95% CI 3,800–8,805 kg) of hatchery salmonids and 924 kg (95% CI 60–3,526 kg) wild salmonids.

4 | DISCUSSION

Non-native brown trout in the Trinity River are highly piscivorous. We found that large individual brown trout relied heavily on native salmonids as prey. This is a particular concern given the ongoing, intensive recovery efforts for native salmonids in the Trinity River. Here, we consider brown trout predation separately on hatchery and wild-spawned fish. We take this approach for three reasons: First, hatchery fish are isotopically distinct from other prey sources due to the marine fish component of hatchery fish feed, so we had to estimate consumption of hatchery fish separately from wild fish in our isotope analysis. Second, hatchery production and release practices

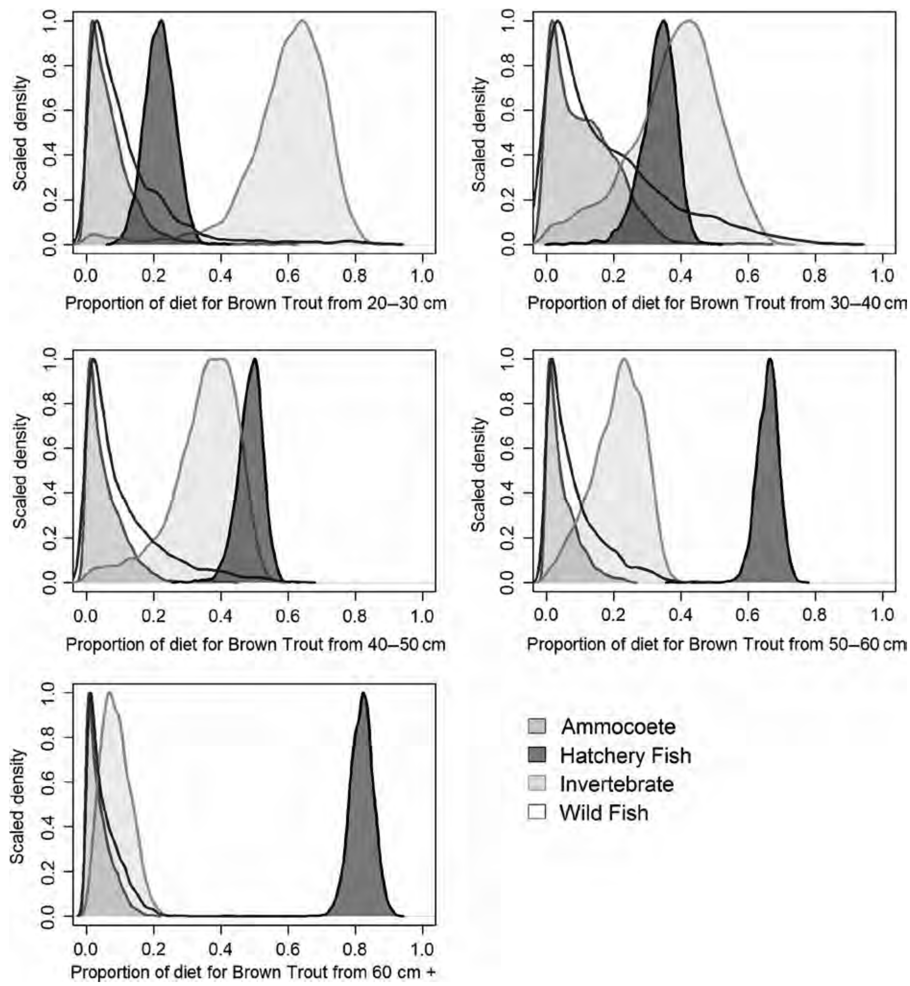

FIGURE 5 Diet proportions of brown trout grouped by fork length. Sample sizes for each size bin were *n* = 19 for 20–30 cm, *n* = 60 for 30–40 cm, *n* = 83 for 40–50 cm, *n* = 61 for 50–60 cm, and *n* = 30 for >60 cm

are factors that managers can control to potentially affect predation rate or brown trout abundance, but this is not true of wild-spawned fish. Third, although the Trinity River hatchery and wild runs of salmon and trout are genetically integrated, hatchery and wild-spawned individuals often have different survival and adult return rates (Araki, Berejikian, Ford, & Blouin, 2008) so predation on each type may have different effects on salmon and trout populations.

4.1 | Hatchery-produced fish

Piscivorous brown trout in the Trinity River relied heavily on hatchery-produced fish. Our isotope analysis indicates that most of the biomass of large brown trout in the Trinity River is derived from consumption of hatchery fish. Other studies have found that releases of large numbers of hatchery-produced fish can provide a substantial resource pulse that alters recipient ecosystems (Alexiades, Flecker, & Kraft, 2017; Warren & McClure, 2012). To put the results for predation on hatchery fish in context with regard to salmon production, the mean estimate of hatchery fish biomass consumed by brown trout was about 7% of the total biomass released from Trinity River Hatchery in 2015.

The artificial subsidy provided by juvenile salmon and trout from the hatchery likely allows Trinity River brown trout to maintain elevated population levels and reach larger size than would otherwise exist within the river. Historical records suggest that the Trinity River brown trout population increased substantially after hatchery releases began, (Moffett & Smith, 1950; Rodgers, 1973) giving some credence

TABLE 3 Comparison of diet composition results based on lavage and isotope analysis

Brown trout size interval (cm)	% Fish: Lavage (%)	% Fish: Isotope (%)
20–30	8	38
30–40	26	60
40–50	83	63
50–60	82	78
>60	98	92

Note. The lavage was calculated as the summed mass of content within a category divided by the total mass of stomach contents. All masses are wet masses and do not account for digestive state. Brown trout are grouped by fork length.

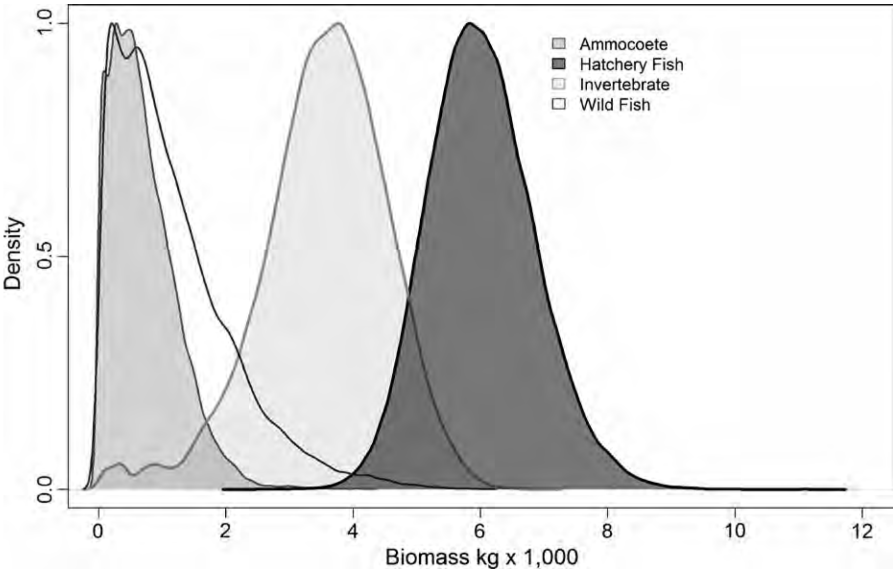

FIGURE 6 Estimated biomass of prey consumed by all brown trout >20 cm long in the Trinity River over the course of a year. Median consumption estimates were 5,930 kg of hatchery fish (95% CI 3,800–8,805 kg) 3,566 kg of invertebrates (95% CI 1,279–5,524 kg), 924 kg (95% CI 60–3,526 kg) of wild fish and 598 kg of lamprey ammocoetes (95% CI 18–2,058 kg)

to the notion that hatchery supplementation increased brown trout population growth, although habitat restoration and changes in flow management probably explain some of the variation in brown trout abundance. Brown trout are currently sustained by hatchery fish even though the availability of hatchery fish is seasonally limited to relatively brief periods after hatchery releases and before the hatchery fish migrate out of the Trinity River heading for the ocean (March for coho salmon, April for steelhead trout, June and October for Chinook salmon). Our bioenergetics model and observations of stomach contents suggest that the large brown trout feed voraciously immediately following hatchery releases and probably do not gain much biomass during the rest of the year. However, brown trout do still eat opportunistically when hatchery fish are not available, including during the vulnerable emergence and early rearing period for wild salmon and trout in the study area (January–February).

There was a clear ontogenetic diet shift for Trinity River brown trout, with increasing reliance on hatchery fish for larger, older individuals. An increase in piscivory with size is a well-documented phenomenon for brown trout (Jensen, Kiljunen, & Amundsen, 2012; L'Abée-Lund, Langeland, & Sægrov, 1992) and is often accompanied by a rapid increase in growth rate and a larger maximum size (Jonsson, Næsje, Jonsson, Saksgård, & Sandlund, 1999). However, recent work suggests that the shift to piscivory is contingent on the presence of a suitable prey species that is vulnerable to brown trout and abundant enough to support a population of predators (Sánchez-Hernández, Eloranta, Finstad, & Amundsen, 2017). Hatchery-released fish may fill this role for brown trout in the Trinity River, supporting a shift to piscivory and sustaining the biomass of large, predatory individuals.

4.2 | Wild-spawned fish

Our estimate of predation on wild-spawned salmon and trout is lower and less precise than the estimate for hatchery-produced fish. The lower precision of this estimate is caused in part by the isotopic similarity of wild salmon and trout to other naturally-occurring prey items in the Trinity River, including insects and lamprey ammocoetes. However, based on observations of fish in brown trout diets before the hatchery releases, we know that brown trout in the Trinity River do actively feed on wild-spawned salmon and trout. Although the total biomass of wild fish that brown trout consume is much lower than for hatchery fish, this predation is still a potential concern for conservation because it occurs over longer time spans, including the early rearing period when the total biomass of wild fish available is much lower than the biomass of hatchery fish available during hatchery releases. However, translating our consumption estimates into mortality rates and estimating the effects of brown trout on wild salmon populations in the Trinity River is not possible with the current data set.

Based on the average estimate of ca. 1,000 kg of wild salmonids consumed by brown trout and a total of ca. 4,000 kg of juvenile salmonids outmigrating from the upper Trinity River (Harris et al., 2016), we could naively say that 20% of wild salmonid production in 2015 was consumed by brown trout. However, this estimate could have a substantial positive or negative bias for a variety of reasons. First, some proportion of the wild salmonids consumed by piscivorous brown trout were juvenile brown trout, which are lumped with other wild-spawned salmon and trout in the isotope analysis (potential positive bias). The lavage data suggest that cannibalism was relatively rare, but our samples from outside of the spring electrofishing sample bouts are limited and cannibalism may have been more common in other seasons. Even if we assume cannibalism was truly rare, the naïve calculation of brown trout imposed mortality is premised on some very unlikely assumptions: that every fish consumed by brown trout was similar in size to outmigrants and that every fish consumed by brown trout would have survived their journey out of the 64 km below the dam if it was not consumed. In reality, brown trout can consume juvenile salmonids during their entire rearing period leading up to outmigration, including at sizes much smaller than outmigrants (potential negative bias). Further, not all of the wild fish consumed by brown trout would have otherwise survived (potential positive bias), some level of compensatory mortality is certain (Ward & Hvidsten, 2010). Finally, any attempt to estimate effects on populations would clearly require estimates of consumption at the species level, not lumped into hatchery and wild categories (unknown bias, possibly different for each prey species).

In addition to predation, brown trout may affect survival and growth of wild-spawned salmon and trout in the Trinity River through competition. Our sampling techniques and analysis focused on large brown trout with diets and microhabitat use that are distinct from native juvenile salmon and trout. However, other studies have found that juvenile brown trout can compete for food and territory space with juveniles of all three salmon and trout species native to the Trinity River (Fausch & White, 1986; Gatz, Sale, & Loar, 1987; Glova & Field-Dodgson, 1995). Competition could exacerbate any negative effects of brown trout on populations of native fish in the Trinity River, as has been suggested for non-native brook trout and native Chinook salmon in the Columbia River system (Levin, Achord, Feist, & Zabel, 2002). Evaluating effects of competition between brown trout and native salmon and trout in the Trinity River will require a new sampling effort.

4.3 | Management options

Historical records are incomplete, but existing information suggests that brown trout abundance in the Trinity River continues to fluctuate. Creel surveys prior to 1970 refer to catches of less than 10 brown trout per angler per year, with fish ranging from 30 to 50 cm (Moffett & Smith, 1950; Rodgers, 1973). Catches in recent years are generally 2–5 brown trout per angler per day with lengths reaching or exceeding 70 cm (J. Alvarez, personal observation). Our sampling in 2015 might represent part of a recent peak in brown trout abundance. As sampling continued into 2016 and 2017, the brown trout population estimates declined and younger year-classes were less common (Alvarez, 2017). Despite this potential recent decrease in brown trout abundance, our results suggest that Trinity River brown trout have the capacity to exist at abundance high enough to consume a substantial proportion of native salmonid production.

The consumption estimates that we produced are contingent on the validity of our bioenergetics model. Bioenergetics models provide a framework for accounting for metabolic costs and other energetic losses when inferring food consumption from observations of growth. The models are based on fundamental relationships between body size, temperature and physiological rates (Hansen et al., 1997). There is a large body of work on the energetics of brown trout growth that describes these relationships (Elliott, 1994), providing the basis for the parameters that we used. However, there are many uncertainties in bioenergetics models that can lead to biased estimates, including uncertainty in the parameter estimates, the functional form of the physiological relationships and how these vary across individuals and populations (Chipps & Wahl, 2008). In our model, we used simulations to incorporate the uncertainty in our field-derived parameter estimates into our estimate of consumption, but there are no estimates of the uncertainty available for most of the basic physiological parameters in the literature. One particular area of concern for our estimate is the highly seasonal pattern of prey availability and consumption, with most of the annual energy intake for large brown trout coming from the consumption of hatchery fish during the spring release. The standard bioenergetics model formulation often underestimates consumption when prey availability is high and overestimates consumption when prey availability is low (Chipps & Wahl, 2008). However, we do not know how these biases play out over time when food availability transitions from very high to low, or how this seasonal variation may affect our isotopic determination of diet composition.

If brown trout are suppressing survival of native salmon and trout, then direct control of brown trout abundance by altering sport harvest regulations, euthanising brown trout captured in the course of other sampling efforts and targeted removal sampling may aid in the recovery of native populations. However, direct control of invasive trout can be very expensive and such efforts have a mixed record of success (Meyer, Lamansky, & Schill, 2006; Syslo et al., 2011). If implemented, any such efforts should include assessment of survival of hatchery-released fish and recruitment success of wild fish to determine whether brown trout control efforts benefit native salmon and trout.

Efforts to manage the brown trout population to reduce impacts on native salmon and trout in the Trinity River are likely to generate some controversy. The authors of previous studies in other regions often comment on the importance of brown trout to the sport fishing community. For example, Belk et al. (2016) investigated the potential for maintaining the fishery for non-native brown trout in the Provo River in Utah while increasing native fish populations through physical habitat restoration. They found that rare species would persist only with low brown trout abundance; negative effects on native species could be ameliorated but not removed while brown trout persisted. Similarly, Townsend (1996) studied streams across New Zealand and found localised extirpations of galaxiid fishes and large-scale changes to entire aquatic communities associated with introduced brown trout. Despite these findings, in his conclusions he questioned the need for and feasibility of any brown trout removal programme. A community of recreational anglers is invested in brown trout in the Trinity River system because resident brown trout support a small recreational fishery, especially when native anadromous species are not available.

As an alternative to direct control efforts, it may be possible to reduce predation on hatchery fish by altering release practices at the hatchery. Reducing brown trout predation on hatchery-released fish has two potential benefits: increased survival of hatchery-released fish, supporting conservation efforts and harvest opportunities, and a reduced subsidy to the brown trout population. The latter could have cascading affects, including reducing the abundance of large, piscivorous brown trout that rely on hatchery-released fish and reducing predation on wild fish. This assumes that brown trout will not be able to sustain their high biomass by switching to an alternative prey, but we argue that this is a reasonable assumption given that large brown trout do not currently consume much biomass of other prey during the portion of the year when hatchery salmon are not available. Approaches that might reduce brown trout predation on hatchery fish include synchronising the releases of multiple species from the hatchery, so that large numbers of prey swamp the brown trout for a lower overall predation rate (Ward & Hvidsten, 2010), and minimising the time that hatchery fish remain in the system by delaying releases until fish are large and set to migrate rapidly to sea.

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REFERENCES

Adkins, R. D. (2007). *The destruction of the Trinity River, California*. Norman, OK: University of Oklahoma.

Alexiades, A. V., Flecker, A. S., & Kraft, C. E. (2017). Nonnative fish stocking alters stream ecosystem nutrient dynamics. *Ecological Applications*, *27*, 956–965. https://doi.org/10.1002/eap.1498

Alvarez, J. S. (2017). *Abundance, growth, and predation by non-native brown trout in the Trinity River, CA*. Masters thesis. Humboldt State University.

Araki, H., Berejikian, B. A., Ford, M. J., & Blouin, M. S. (2008). Fitness of hatchery-reared salmonids in the wild. *Evolutionary Applications*, *1*, 342–355. https://doi.org/10.1111/j.1752-4571.2008.00026.x

Beechie, T. J., Pess, G. R., Imaki, H., Martin, A., Alvarez, J., & Goodman, D. H. (2015). Comparison of potential increases in juvenile salmonid rearing habitat capacity among alternative restoration scenarios, Trinity River, California. *Restoration Ecology*, *23*, 75–84. https://doi.org/10.1111/rec.12131

Belk, M., Billman, E., Ellsworth, C., & McMillan, B. (2016). Does habitat restoration increase coexistence of native stream fishes with introduced brown trout: A case study on the Middle Provo River, Utah, USA. *Water*, *8*, 121. https://doi.org/10.3390/w8040121

Borok, S., Cannata, S., Hileman, J., Hill, A., & Kier, M. C. (2014). *Trinity River basin salmon and steelhead monitoring project, 2012–2013 season*. Redding, CA: California Department of Fish and Wildlife.

Borok, S., Cannata, S., Hill, A., Hileman, J., & Kier, M. C. (2014). *Trinity River basin salmon and steelhead monitoring project, 2011–2012 season (Annual Report)*. Redding, CA: California Department of Fish and Wildlife.

Burke, B. J., & Rice, J. A. (2002). A linked foraging and bioenergetics model for southern flounder. *Transactions of the American Fisheries Society*, *131*, 120–131.

California Fish and Game Commission (2007). *Notice of proposed changes in regulations*. Amend Subsection 7.50(b)(91.1), Title 14, CCR, Klamath River Basin Sport Fishing.State of California.

California Hatchery Scientific Review Group (2012). *California hatchery review report*. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 100 pgs.

Chipps, S. R., & Wahl, D. H. (2008). Bioenergetics modeling in the 21st century: Reviewing new insights and revisiting old constraints. *Transactions of the American Fisheries Society*, *137*, 298–313. https://doi.org/10.1577/T05-236.1

Clutter, R. I., & Whitesel, L. E. (1956). *Collection and interpretation of sockeye salmon scales*. Madison, WI: International Pacific Salmon Fisheries Commission. Bulletin IX.

Dieterman, D. J., Thorn, W. C., & Anderson, C. S. (2004). *Application of a bioenergetics model for brown trout to evaluate growth in southeast Minnesota streams*. Minnesota Department of Natural Resources Investigational Report. 513: 1–27.

Dill, W. A., & Cordone, A. J. (1997). *History and status of introduced fishes in California, Fish Bulletin 178*. Sacramento, CA: California Department of Fish and Game.

Dunn, A., Francis, R. I. C. C., & Doonan, I. J. (2002). Comparison of the Chapman-Robson and regression estimators of Z from catch-curve data when non-sampling stochastic error is present. *Fisheries Research*, *59*, 149–159. https://doi.org/10.1016/S0165-7836(01)00407-6

Elliott, J. M. (1994). *Quantitative ecology and the brown trout*. Oxford, CA: Oxford University Press.

Fausch, K. D., & White, R. J. (1986). Competition among juveniles of coho salmon, brook trout, and brown trout in a laboratory stream, and implications for Great Lakes tributaries. *Transactions of the American Fisheries Society*, *115*, 363–381. https://doi.org/10.1577/1548-8659(1986)115<363:CAJOCS>2.0.CO;2

Flinders, J. M. (2012). *Stable isotope analysis (δ^{15}nitrogen and δ^{13} carbon) and bioenergetic modeling of spatial-temporal foraging patterns and consumption dynamics in brown and rainbow trout populations within catch-and-release areas of Arkansas tailwaters*. PhD thesis, University of Arkansas.

Gatz, A. J., Sale, M. J., & Loar, J. M. (1987). Habitat shifts in rainbow trout: Competitive influences of brown trout. *Oecologia*, *74*, 7–19. https://doi.org/10.1007/BF00377339

Glova, G. J., & Field-Dodgson, M. S. (1995). Behavioral interaction between Chinook salmon and brown trout juveniles in a simulated stream. *Transactions of the American Fisheries Society*, *124*, 194–206. https://doi.org/10.1577/1548-8659(1995)124<0194:BIBCSA>2.3.CO;2

Goodman, D. H., Som, N. A., Alvarez, J., & Martin, A. (2015). A mapping technique to evaluate age-0 salmon habitat response from restoration. *Restoration Ecology*, *23*, 179–185. https://doi.org/10.1111/rec.12148

Groot, C., Margolis, L., & Clarke, W. C. (1995). *Physiological ecology of Pacific salmon*. Vancouver, BC: UBC Press.

Hansen, P., Johnson, T., Kitchell, J., & Schindler, D. E. (1997). *Fish bioenergetics 3.0 (No. WISCU-T-97-001)*. Madison, WI: University of Wisconsin Sea Grant Institute.

Harris, N. J., Petros, P., & Pinnix, W. D. (2016). *Juvenile salmonid monitoring on the mainstem Trinity River, California, 2015*. Yurok Tribal Fisheries Program, Hoopa Valley Tribal Fisheries Department, and U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office. Arcata Fisheries Data Series Report Number DS 2016–46, Arcata, California.

Hoxmeier, R. J. H., & Dieterman, D. J. (2016). Long-term population demographics of native brook trout following manipulative reduction of an invader. *Biological Invasions*, *18*, 2911–2922.

Jensen, H., Kiljunen, M., & Amundsen, P. A. (2012). Dietary ontogeny and niche shift to piscivory in lacustrine brown trout *Salmo trutta* revealed by stomach content and stable isotope analyses. *Journal of Fish Biology*, *80*, 2448–2462. https://doi.org/10.1111/j.1095-8649.2012.03294.x

Jonsson, N., Næsje, T. F., Jonsson, B., Saksgård, R., & Sandlund, O. T. (1999). The influence of piscivory on life history traits of brown trout. *Journal of Fish Biology*, *55*, 1129–1141.

L'Abée-Lund, J. H., Langeland, A., & Sægrov, H. (1992). Piscivory by brown trout *Salmo trutta* L. and Arctic charr *Salvelinus alpinus* L. in Norwegian lakes. *Journal of Fish Biology*, *41*, 91–101. https://doi.org/10.1111/j.1095-8649.1992.tb03172.x

Levin, P. S., Achord, S., Feist, B. E., & Zabel, R. W. (2002). Non–indigenous brook trout and the demise of Pacific salmon: A forgotten threat? *Proceedings of the Royal Society of London B: Biological Sciences*, *269*, 1663–1670.

MacCrimmon, H. R., & Marshall, T. L. (1968). World distribution of brown trout, *Salmo trutta*. *Journal of the Fisheries Research Board of Canada*, *25*, 2527–2549. https://doi.org/10.1139/f68-225

McCutchan, J. H., Lewis, W. M., Kendall, C., & McGrath, C. C. (2003). Variation in trophic shift for stable isotope ratios of carbon, nitrogen, and sulfur. *Oikos*, *102*, 378–390. https://doi.org/10.1034/j.1600-0706.2003.12098.x

McHugh, P., & Budy, P. (2006). Experimental effects of nonnative brown trout on the individual- and population-level performance of native Bonneville cutthroat trout. *Transactions of the American Fisheries Society*, *135*, 1441–1455. https://doi.org/10.1577/T05-309.1

Meyer, K. A., Lamansky, J. A., & Schill, D. J. (2006). Evaluation of an unsuccessful brook trout electrofishing removal project in a small rocky Mountain stream. *North American Journal of Fisheries Management*, *26*, 849–860. https://doi.org/10.1577/M05-110.1

Minagawa, M., & Wada, E. (1984). Stepwise enrichment of 15N along food chains: Further evidence and the relation between δ15N and animal age. *Geochimica et Cosmochimica Acta*, *48*, 1135–1140. https://doi.org/10.12691/marine-1-1-4

Moffett, J. W., & Smith, S. E. (1950). *Biological investigations of the fishery resource of Trinity River, Calif. U.S*. Fish and Wildlife Service, Special Scientific Report: Fisheries No.12.

Myrvold, K. M., & Kennedy, B. P. (2015). Interactions between body mass and water temperature cause energetic bottlenecks in juvenile steelhead. *Ecology of Freshwater Fish*, *24*, 373–383. https://doi.org/10.1111/eff.12151

National Marine Fisheries Service (2014). *Final recovery plan for the Southern Oregon/Northern California coast evolutionarily significant unit of coho salmon (*Oncorhynchus kisutch*)*. Arcata, CA: National Marine Fisheries Service.

Peterson, B. J., & Howarth, R. W. (1987). Sulfur, carbon, and nitrogen isotopes used to trace organic matter flow in the salt-marsh estuaries of Sapelo Island, Georgia. *Limnology and Oceanography*, *32*, 1195–1213. https://doi.org/10.4319/lo.1987.32.6.1195

Phillips, D. L., & Gregg, J. W. (2003). Source partitioning using stable isotopes: Coping with too many sources. *Oecologia*, *136*, 261–269. https://doi.org/10.1007/s00442-003-1218-3

Pickering, A. D., Pottinger, T. G., & Christie, P. (1982). Recovery of the brown trout, *Salmo trutta* L., from acute handling stress: A time-course study. *Journal of Fish Biology*, *20*, 229–244. https://doi.org/10.1111/j.1095-8649.1982.tb03923.x

R Development Core Team (2009). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Rodgers, D. W. (1973). *The sport fishery on the Trinity River below Lewiston Dam from March 1, 1968 to July 31, 1969*. California Department of Fish and Game, Administrative Report 73–9.

Sánchez-Hernández, J., Eloranta, A. P., Finstad, A. G., & Amundsen, P. A. (2017). Community structure affects trophic ontogeny in a predatory fish. *Ecology and Evolution*, *7*, 358–367. https://doi.org/10.1002/ece3.2600

Seber, G. A. F. (1982). *The estimation of animal abundance and related parameters*. 2nd ed. London, UK: Griffin.

Sinnen, W., Currier, M., Knechtle, M., & Borok, S. (2005). *Trinity River basin salmon and steelhead monitoring project 2005–2006 season (Annual Report No. 90830)*. North Coast Region: California Department of Fish and Game.

Stock, B. C., & Semmens, B. X.(2013). *Package 'MixSIAR' (R package)*.

Syslo, J. M., Guy, C. S., Bigelow, P. E., Doepke, P. D., Ertel, B. D., & Koel, T. M. (2011). Response of non-native lake trout (*Salvelinus namaycush*) to 15 years of harvest in Yellowstone Lake, Yellowstone National Park. *Canadian Journal of Fisheries and Aquatic Sciences*, *68*, 2132–2145. https://doi.org/10.1139/f2011-122

Thomas, J. L. (1981). *Historical notes on the brown trout in Trinity County*. Sacramento, CA: California Department of Fish and Game.

Townsend, C. R. (1996). Invasion biology and ecological impacts of brown trout *Salmo trutta* in New Zealand. *Invasion Biology*, *78*, 13–22. https://doi.org/10.1016/0006-3207(96)00014-6

Trinity Journal newspaper article (1911). *New trout sent to Trinity County; Scottish variety to supplant the famous rainbow species*. Redding, California.

Van Alen, B. W.(1982). *Use of scale patterns to identify the origins of Sockeye Salmon (Oncorhynchus nerka) in the fishery of Nushagak Bay, Alaska*. Informational Leaflet No. 202. Alaska Department of Fish and Game.

Vander Zanden, M. J., Cabana, G., & Rasmussen, J. B. (1997). Comparing trophic position of freshwater fish calculated using stable nitrogen isotope ratios ($\delta^{15}N$) and literature dietary data. *Canadian Journal of Fisheries and Aquatic Sciences*, *54*, 1142–1158. https://doi.org/10.1139/f97-016

Vander Zanden, M., & Rasmussen, J. B. (2001). Variation in δ15N and δ13C trophic fractionation: Implications for aquatic food web studies. *Limnology and Oceanography*, *46*, 2061–2066. https://doi.org/10.4319/lo.2001.46.8.2061

Ward, D. M., & Hvidsten, N. A. (2010). Predation: Compensation and context dependence. In Ø. Aas, A. Klemetsen, S. Einum, & J. Skurdal (Eds.), *Atlantic salmon ecology* (pp. 199–220). Oxford, UK: Wiley-Blackwell.

Warren, D. R., & McClure, M. M. (2012). Quantifying salmon-derived nutrient loads from the mortality of hatchery-origin juvenile Chinook salmon in the Snake River basin. *Transactions of the American Fisheries Society*, *141*, 1287–1294. https://doi.org/10.1080/00028487.2012.686950

Wilson, S. (1879). *Salmon at the Antipodes: Being an account of the successful introduction of salmon and trout into Australian waters*. London, UK: Edward Stanford.

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July 22, 2019

Eric Sklar
President, California Fish and Game Commission
PO Box 94209
Sacramento, CA 94244-2090

Dear Mr. Sklar:

I am writing to you as an individual who holds a Bachelor's Degree in Environmental Studies from Sonoma State University with an emphasis in Parks and Natural Resources. My studies included Biodiversity (endangered species), fire ecology, geology, and field biology. I am also the daughter of Theodore E. Adams, Jr., formerly of the University of California, Cooperative Extension in the Agronomy Department at the University of California at Davis. He was a wildland specialist and dealt with range management and erosion control. I am sure you can appreciate my background at this point.

I am writing to you regarding the seasonal dam at Trinity Alps Resort, Trinity Center, CA. The resort was built in the 1920's and has been temporarily damming the stream from around July 4th to around September 30th every year (depending on the water level) to create a swimming hole for the guests. So I am sure that if there were truly any effects on the yellow legged frog this would have been a problem much earlier than now. Especially since the California Department of Fish and Game has recognized the main issue of the yellow legged frog being due to an introduction of a nonnative trout species into our lakes and streams, along with the use of pesticides, livestock grazing and of course, global warming (climate change) of which Trinity Alps Resort has no control over or participates in the above causes.

Last year, we became aware that the owner, Margo Gray, was having issues obtaining a permit for the dam. The dam is not what is affecting these frogs. It seems more likely caused by the predation from the nonnative trout introduced into an already balanced ecosystem. I am not sure how one small dam is going to affect the outcome when the causes are already clearly stated. I had no problem researching this information.

This year, Margo Gray has not been given permission for the dam yet. This affects the economy of the area tremendously as Trinity Alps Resort guests provide much needed economic support to an otherwise depressed area. We spend a lot of money in Trinity County when we come up here. The guests are people who come up every year and have done so for decades, including my family. We have been vacationing at Trinity Alps Resort since 1974. The local people and businesses depend on the money coming in. Trinity County will become an even more depressed area if Trinity Alps Resort guests decide to change their vacation venues to other areas that offer a similar venue. Trinity Alps Resort also provides jobs that would otherwise be nonexistent. The swimming hole is the focal point of the resort. No dam equals no jobs and no money.

Thank you for taking the time to ready my letter. I hope it will be part of the decision process.

Sincerely,

Linda Adams

Notification of Intent to file a petition to list Shasta Snow-Wreath (Neviusia cliftonii) under US ESA

Kathleen Roche [redacted]
Thu 08/22, 02:26 PM

Kathleen S. Roche, [redacted]

August 22, 2019

To: Melissa Miller-Henson
Acting Executive Director
fgc@fgc.ca.gov
California Fish and Game Commission
P.O. Box 944209, Sacramento, CA 94244-2090

CC: The Honorable Margaret Everson
Principal Deputy Director, U.S. Fish and Wildlife Service Exercising the Authority of the Director for the U.S. Fish and Wildlife Service U.S. Fish and Wildlife Service
1849 C Street NW, Room 3331 Washington, DC 20240-000

Margaret_Everson@fws.gov

Paul Souza
USFWS Pacific Southwest Region Headquarters and Organization
2800 Cottage Way, Sacramento, Calif. 95825

Paul_Souza@fws.gov

To: California Fish and Game Commission and U.S. Fish and Wildlife Service:

Pursuant to US 50 C.F.R. §424.14(b), I, Kathleen S. Roche, hereby provide notice that I intend to file a petition under the federal Endangered Species Act to list and designate critical habitat for the Shasta snow-wreath,*Neviusia cliftonii*, no sooner than 30 days from the date that this notice is provided. This petition has been prepared with the participation of the California Native Plant Society and uses all available scientific information from the State of California.

The Shasta snow-wreath is a dicot, shrub in the rose family (Rosaceae) that is native to California and is endemic (limited) to northern California. The species was first described in 1992 and is now known from a total of 24 occurrences, restricted almost entirely to National Forest System lands, with six occurrences wholly or partly on private lands, including industrial forest lands. It is found exclusively in western Shasta County around the perimeter of Shasta Lake in northern California. It is one of only two species in the genus *Neviusia*. There are no other species of *Neviusia* in California nor adjacent states. There is agreement on the classification and the scientific name of this species (California Natural Diversity Database (California Department of Fish and Wildlife), Calflora, NatureServe, USDA Plants Database, the Jepson eFlora, and the Flora of North America). The species currently holds a NatureServe global rank of G2 and a California Rare Plant Rank of 1B.2. **The Shasta snow-wreath is endangered by the proposed destruction of habitat primarily by water inundation from raising Shasta Dam and accessory activities to relocate facilities as well as by other actions.**

The USFWS has not previously reviewed this species for listing, nor has the California Fish and Game Commission reviewed it for listing under the California Endangered Species Act (CESA).

Please feel free to contact me for more information.

Kathleen S. Roche

I am also sending you a paper copy of this notification via surface mail.

FONSI for a Management Plan for Developed Water Sources, Mojave National Preserve

christopher_nolan@nps.gov on behalf of MOJA Superintendent, NPS <moja_superintend

Fri 08/23, 08:24 AM

Mojave National Preserve News Release

Release Date: August 22, 2019

Contact: Todd Suess, Mojave National Preserve, (760) 252-6103

Finding of No Significant Impact for a Management Plan for Developed Water Sources, Mojave National Preserve

BARSTOW—The National Park Service has approved a Management Plan for Developed Water Sources in Mojave National Preserve (Plan). The decision was recorded through the approval of a Finding of No Significant Impact.

The NPS selected the preferred alternative of the Plan, which will maintain essential wildlife water developments in wilderness and install new water developments outside of wilderness to improve regional habitat connectivity. The number of water developments for desert bighorn sheep will increase from six to eleven during a multi-year transition period. Based on the results of water use analysis, some of these water developments could be consolidated.

Key points include:

- The NPS will work collaboratively with the California Department of Fish & Wildlife (CDFW) and stakeholders to ensure all decisions regarding water developments are consistent, to the extent possible, with the CDFW Bighorn Sheep Management Plan.
- Selected water developments for birds and small game outside of wilderness will be evaluated and maintained according to their ecological importance.
- Developed springs will be evaluated and maintained based on feasibility and importance.

The selected alternative utilizes water developments for supporting native wildlife and habitat connectivity while protecting wilderness values. Relocating water developments for bighorn sheep to areas with easier access will facilitate their maintenance.

-NPS-

About the National Park Service. More than 20,000 National Park Service employees care for America's 419 national parks and work with communities across the nation to help preserve local history and create close-to-home recreational opportunities. Learn more at www.nps.gov.

County of Santa Cruz

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701 OCEAN STREET, SUITE 500, SANTA CRUZ, CA 95060-4069
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August 27, 2019

California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

RE: SUPPORT FOR CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE (DFW) LOW FLOW ANGLING CLOSURE

Dear California Fish and Game Commission,

I am writing to you on behalf of the Santa Cruz County Board of Supervisors to convey our strong support for current efforts to study and propose a finalized low flow target for temporary closures of recreational steelhead angling in Santa Cruz County waterways. While most steelhead and salmon streams throughout California have finalized closure thresholds in the accepted Sport Fishing Regulations, Santa Cruz County does not. Low flow fishing thresholds will provide and maintain angling opportunities, enhance protection of listed salmonids during stressful low flow conditions, simplify regulations and align Santa Cruz County with existing thresholds statewide.

Recent years of exceptional drought and low winter flow conditions have raised concerns about the potential adverse impacts of steelhead angling during critically dry conditions. During periods of low flow, adult steelhead are unable to migrate and are more vulnerable to getting caught multiple times or getting caught while spawning. Short winter storms sometimes allow adult salmonids (steelhead and salmon) to enter local creeks and streams but they may be unable to migrate further when stream flows recede. Young steelhead, including smolts ready to migrate to the ocean, are also more vulnerable to getting caught during winter low flow angling. The low-flow fishing closure criteria would draw from United States Geological Survey (USGS) gage data, which is easily available online. Implementation of low flow angling closures will protect salmonids by working to offset these possible negative effects.

Over the past year, the local CDFW fishery biologist has conducted outreach to fishing groups and anglers, successfully gathering support for the low-flow fishing regulations among both salmonid conservation and angling interest groups. For anglers, the establishment of low-flow fishing closure criteria avoids the risk of a possible closure blanketing more of the fishing season by the State Fish and Game Commission. The Santa Cruz County's Fish and Wildlife Advisory Commission discussed this issue at a meeting in Fall 2018. Enacting low-flow fishing closure criteria can maintain and build support for fishing - an important local recreational activity - while protecting our sensitive steelhead fishery.

The Santa Cruz County Board of Supervisors looks forward to analysis by the DFW regarding modifying existing Supplemental Regulation 8.00 (c) of the 2018 California Freshwater Sports Fishing Regulations regarding closure thresholds for stream flows.

Thank you for your consideration of this letter of support.

Sincerely,

RYAN COONERTY, Chair
Board of Supervisors

cc: Clerk of the Board
County Fish and Wildlife Advisory Commission

(No subject)

Nancy Dunn [redacted]
Fri 09/06, 10:56 AM

I wanted to let you know that under our Creators law all of His creatures are assigned by him to life.We dont actually have a right to take their lives .We respect God wants them to live His length of time. He also didnt assign them for food. They need space and food replenishment on their land. That includes Marine life who have also suffered terrtbly from our ignoring their starvation in the name of a hunt or licence. Hunting also leaves blood scent a safety hazard since those forced to injest it are very sensitive to to it and it really does not help conserve. The ither creatures cope withe verything we cope with plus selfish humans contamination not enough space r oads and birds are also plighted and they cope with aviators who ignore flyways. I have not seen a duck in years alive and am getting used to missing species appearing on cat and dog food cans. Marine life dropped an entire species in one summer of whales. In addition we have more than we can handle of the drug people who think they reserve a right to grab what they find and butcher it without mercy because their money is gone or theyve been permitted to behave barbaric . For that alone we dont need any of it permission ed That includes the USDA who think nothing of being inhumane and are not a good example.

Wildlife conservation

Nick Buckley

Tue 09/10, 07:22 AM

Commissioners,

I have grown very tired of wildlife conservation being dictated by politicians (yourselves) rather than biologists who would use a SCIENCE based approach to wildlife management. The nepotism is so thick within the fish and game commission that responsible wildlife management is being suffocated under the weight of your political agendas. Every decision you have made within the past 8-10 years at a minimum has put wildlife in a more compromised position than before.

Sincerely,
Nick Buckley

Sent from my iPhone

August 30, 2019

CALIFORNIA FISH AND GAME COMMISSION
2019 SEP 11, 2019 2:30

Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

Department of Fish and Wildlife
Northern Region
601 Locust Street
Redding, CA 96001

Department of Fish and Wildlife
Wildlife Branch
P.O. Box 944209
Sacramento, CA 94244-2090
Attn: Victoria Barr

Dear Fish and Game Commission and Department of Fish and Wildlife:

In accordance with the Department of Fish and Wildlife's (Department) Private Lands Management (PLM) Program Policies and Procedures Handbook (March 2008), this letter serves as my notice to the Fish and Game Commission and the Department that I am withdrawing from the PLM Program, effective immediately. I understand that in doing so, my current PLM license and license agreement associated with Triple B Ranch, and therefore my PLM tags and seals, which I returned to the Department on August 12, 2019, will no longer be valid. I did not use any of the tags and seals and the fees for the tags and seals had already been paid in full. As a result, I did not receive any exchange tags and I do not owe any fees.

This letter also serves as notice that I am no longer acting as manager, operator, or in any other capacity of any other PLM, in particular, for JS Ranch, Dixie Valley Ranch, and Clover Creek Ranch. To that end, I have given the landowners of those ranches any of their PLM tags and seals that were in my possession.

Sincerely,

Steve Boero
Owner, Triple B Ranch

Attention Commissioner

Kristen Annis [redacted]

Wed 09/18, 09:00 AM

Attention Commissioner,

I have been a hunter for 40 years in California. This year you went to steel shot for Upland game birds. This season on Sept 1st for Dove. We were using #6 steel shot and the majority of every bird that we shot they were still alive after shooting them. Steel shot is ruining our barrel's and there also is a shortage of steel shot #7 in this State. The manufacturer's are not going to be supplying sufficient #7 steel shot to California, because California is the only state requiring Steel shot #7 for Upland Game. Also in California you cannot use slugs for hunting because they do not make a non lead slug. Also in California you can no longer use a .22 to hunt with because manufacturers do not make a non lead .22 caliber. These laws are affecting many hunters as myself. I completely disagree with these requirements all because of the Condor and other animals that ingest lead supposedly. Please consider my concerns and frustration by these outlandish requirements by the State of California.

Brett Bunge

From Menifee, CA

[redacted]

State of California
Department of Fish and Wildlife

Received on October 1, 2019
Original signed copy on file.

Date: October 1, 2019

To: Melissa Miller-Henson
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Status Review of the Foothill Yellow-legged Frog**

The Department of Fish and Wildlife (Department) prepared the attached Status Review for the Fish and Game Commission (Commission) regarding a petition by the Center for Biological Diversity (Petition) to list the Foothill Yellow-legged Frog (*Rana boylii*) as threatened pursuant to the California Endangered Species Act (CESA; Fish and Game Code section 2074.6). The Commission received the Petition on December 14, 2016. The attached report represents the Department's final written review of the status of the Foothill Yellow-legged Frog and is based upon the best scientific information available to the Department. In addition to evaluating the petitioned action to list the species as threatened, the Department evaluated whether listing the species was warranted for six unique genetic clades. The status review contains the Department's recommendation that listing the Foothill Yellow-legged Frog is warranted at this time for five of six genetic clades. The Department recommends listing the Feather River and Northeast/Northern Sierra clades as threatened and listing the East/Southern Sierra, West/Central Coast, and Southwest/South Coast clades as endangered. Listing the Northwest/North Coast clade is not warranted at this time.

Regarding the scientific determinations of the threats to the Foothill Yellow-legged Frog, the Department finds that without protections afforded by CESA, the continued existence of the Foothill Yellow-legged Frog throughout much of its range in California is in serious danger or is threatened as described in the report.

If you have any questions or need additional information, please contact Kari Lewis, Chief, Wildlife Branch at (916) 445-3789 or at Kari.Lewis@wildlife.ca.gov.

Attachment

STATE OF CALIFORNIA
NATURAL RESOURCES AGENCY
DEPARTMENT OF FISH AND WILDLIFE

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF THE **FOOTHILL YELLOW-LEGGED FROG** (*Rana boylii*) IN CALIFORNIA

CHARLTON H. BONHAM, DIRECTOR
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

September 20, 2019

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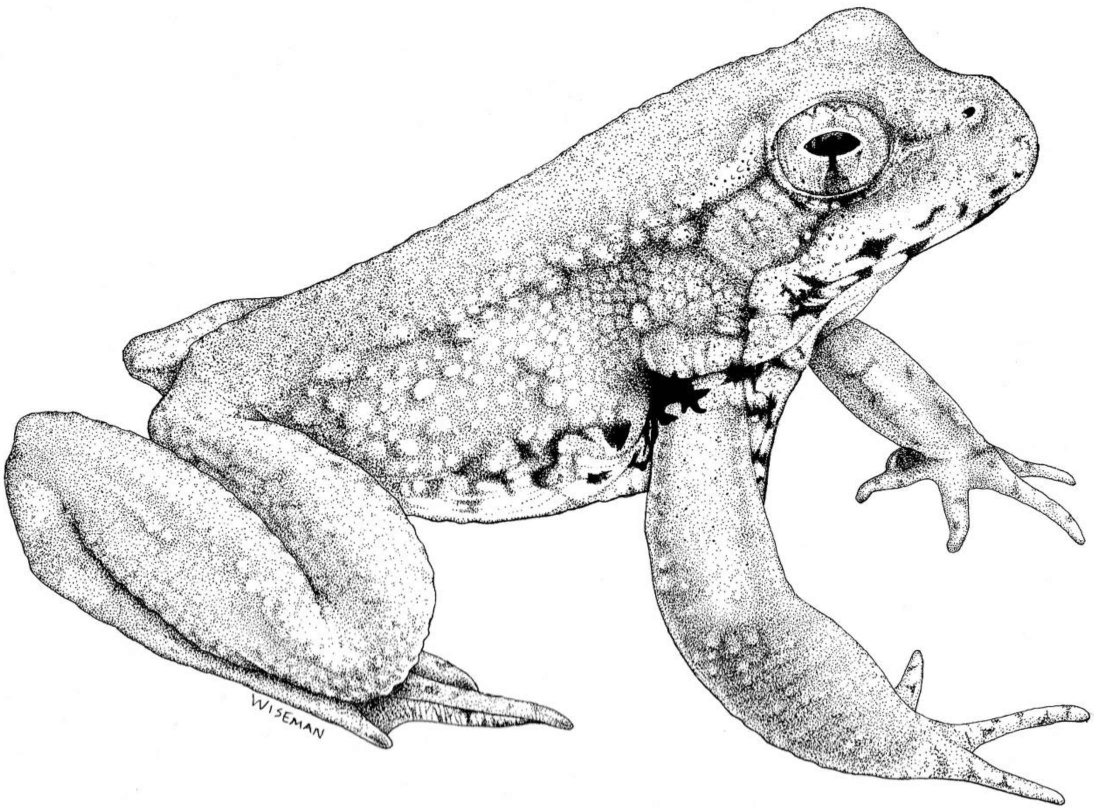

ACKNOWLEDGMENTS

Laura Patterson prepared this report. Stephanie Hogan, Madeleine Wieland, and Margaret Mantor assisted with portions of the report, including the sections on Status and Trends in California and Existing Management. Kristi Cripe provided GIS analysis and figures. Review of a draft document was provided by the following California Department of Fish and Wildlife (Department) staff: Ryan Bourque, Marcia Grefsrud, and Mike van Hattem.

The Department is extremely grateful for the valuable comments provided on this report by the following peer reviewers: Dr. Sarah Kupferberg, Dr. Amy Lind, Dr. Jim McGuire, and Dr. Ryan Peek. The conclusions in this report are those of the Department and do not necessarily reflect those of the reviewers.

Cover photograph by Isaac Chellman, used with permission.

Illustration by Kevin Wiseman, used with permission.

EXECUTIVE SUMMARY

This status review report contains the most current information available on the Foothill Yellow-legged Frog (*Rana boylii*) and serves as the basis for the California Department of Fish and Wildlife's (Department) recommendation to the California Fish and Game Commission (Commission) on whether to list the species as threatened or endangered under the California Endangered Species Act. The Center for Biological Diversity submitted a "Petition to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened Under the California Endangered Species Act" (Petition) to the Commission on December 14, 2016. At its scheduled public meeting on June 21, 2017, the Commission considered the Petition, and based in part on the Department's petition evaluation and recommendation, found sufficient information exists to indicate the petitioned action may be warranted and accepted the Petition for consideration. The Foothill Yellow-legged Frog was designated a candidate species on July 7, 2017 upon publication of the Commission's notice of its findings.

Foothill Yellow-legged Frogs are currently recognized as a California Species of Special Concern, a non-regulatory designation intended to focus attention on animals at conservation risk, stimulate research on poorly known species, and achieve conservation and recovery of these animals before they meet criteria for listing as threatened or endangered under the California Endangered Species Act (CESA; Fish & G. Code, § 2050 et seq.). Additionally, the Foothill Yellow-legged Frog throughout its range in California and Oregon is currently under review by the U.S. Fish and Wildlife Service for listing as threatened or endangered under the federal Endangered Species Act.

Foothill Yellow-legged Frogs are small- to medium-sized frogs that are typically gray, brown, olive, or reddish with brown-black flecking and mottling, which often matches the local substrate. Foothill Yellow-legged Frogs have a relatively squat body and granular skin, giving them a rough appearance like toads, and their dorsolateral folds are indistinct compared to other western North American ranids. Their abdomen is white with variable amounts of dark mottling on the chest and throat, and as their name suggests, the undersides of their hind limbs are often yellow. Foothill Yellow-legged Frogs reach sexual maturity around two to three years old and can live over a decade. Adult females likely lay one clutch of eggs per year. Egg masses resemble a cluster of grapes with several hundred embryos, and tadpoles metamorphose in the same season the eggs were laid.

Foothill Yellow-legged Frogs historically ranged from the Willamette River drainage in Oregon west of the Sierra-Cascade crest to at least the San Gabriel River drainage in Los Angeles County in California, and a disjunct population was discovered in the mid-1960s in the Sierra San Pedro Mártir, Baja California Norte, México. In California, the species has been reported from foothill and mountain streams in the Klamath, Cascade, Sutter Buttes, Coast, Sierra Nevada, and Transverse ranges from sea level to 6,400 ft, although rarely above 5,000 ft. Foothill Yellow-legged Frog populations exhibit strong genetic variation across their range. Two recent landscape genomics studies recovered five and six deeply divergent clades, respectively, and genetic diversity within clades is generally lower in the southern part of the species' range, making them less capable of adapting to changing conditions.

Foothill Yellow-legged Frogs inhabit rivers and streams ranging from primarily rain-fed (coastal populations) to primarily snow-influenced (most Sierra Nevada and Klamath-Cascade populations) from headwater streams to large rivers. Occupied rivers and streams flow through a variety of vegetation types including hardwood, conifer, and valley-foothill riparian forests; mixed chaparral; and wet meadows. The species is an obligate stream-breeder, which sets it apart from other western North American ranid frogs. Foothill Yellow-legged Frog habitat is generally characterized as partly-shaded, shallow, perennial rivers and streams with a low gradient and rocky substrate that is at least cobble-sized; however, the species also uses intermittent and ephemeral streams. Appropriate flow velocity, temperature, and timing are critically important to the success of Foothill Yellow-legged Frog populations. The habitats in which Foothill Yellow-legged Frogs are found can generally be categorized as breeding and rearing habitat, nonbreeding season habitat, and overwintering habitat. Foothill Yellow-legged Frog densities are often higher in areas with greater habitat heterogeneity likely because the diversity of habitats can support all life stages within a relatively short distance.

Foothill Yellow-legged Frog diet varies by life stage and likely by body size. Tadpoles graze on algae scraped from rocks and vegetation. Post-metamorphic Foothill Yellow-legged Frogs primarily feed on a wide variety of terrestrial arthropods but also some aquatic invertebrates, mostly insects and arachnids. In the fall when they are abundant, young-of-year Foothill Yellow-legged Frogs may provide an important source of nutrition for adults prior to overwintering. Foothill Yellow-legged Frogs are preyed upon by several native and introduced species, including aquatic insects, crayfish, salamanders, frogs, birds, and several species of fish and gartersnakes.

Few historical data on Foothill Yellow-legged Frog distribution and abundance exist, but widespread disappearances were documented as early as the 1970s and 80s in southern California, the southern Coast Range, and the central and southern Sierra Nevada foothills. In 1994, the authors of the first edition of *Amphibians and Reptile Species of Special Concern in California* concluded that Foothill Yellow-legged Frogs could be considered endangered in central and southern California south of the Salinas River in Monterey County, threatened in the west slope drainages of the Cascade Mountains and Sierra Nevada east of the Central Valley, and a species of special concern in the remainder of California.
In 2005, a range-wide assessment determined the species was likely extirpated from over 50% of historically occupied sites, and in another wide-ranging survey effort at least one Foothill Yellow-legged Frog was detected at 26.5% of sites with suitable habitat in California. In the latter study, fewer than 20 adults were observed at approximately 86% of the occupied sites, but the North Coast possessed the greatest proportion of occupied sites and most robust populations. The coarse-scale trend of Foothill Yellow-legged Frog populations in California is one of greater declines and extirpations in lower elevations and latitudes.

Several past and ongoing activities have changed the watersheds upon which Foothill Yellow-legged Frogs depend, and many interact with each other in ways that exacerbate their adverse impacts. In addition, because many Foothill Yellow-legged Frog populations are small, isolated from other populations, and possess low genetic diversity, they are at greater risk of extirpation than robust populations.

Most of the factors threatening the Foothill Yellow-legged Frog's ability to persist and thrive involve habitat destruction or degradation. The most widespread, and potentially most significant, impacts are associated with dams and their flow regimes, particularly in areas where dams are concentrated and occur in a series along a river or use hydropeaking to generate power. Dams can result in up- and downstream effects, including aseasonal or asynchronous breeding cues, scouring and stranding of egg masses and tadpoles, reducing quality and quantity of breeding and rearing habitat, lessening tadpole growth rate, impeding gene flow among populations, and creating conditions that support the establishment and spread of non-native species. The average abundance of Foothill Yellow-legged Frog populations below dams is one-fifth of those in unregulated rivers (undammed), and populations in regulated rivers face a 4- to 13-fold greater extinction risk in 30 years than populations in unregulated rivers due to smaller population sizes.

Another widespread threat to Foothill Yellow-legged Frog habitat is climate change. While drought, wildland fires, floods, and landslides are natural and often necessary disturbance events for preservation of native biodiversity, climate change is expected to result in increased frequency and severity of these events in ways that may exceed species' abilities to adapt. These disturbance events, which can lead to local extirpations, will occur across a landscape of fragmented and small populations, so the likelihood of natural recolonization may be highly impaired. Some climate models predict unprecedented dryness in the latter half of the century, and altered flow regimes may lead to increased competition, predation, and disease transmission as species become concentrated in remnant pools. Impacts from extended droughts will likely be greatest in areas that are naturally more arid, the lower elevations and latitudes of southern California and the foothills surrounding the Central Valley, where remaining populations are already small and isolated. In addition, loss of riparian vegetation from wildland fires can result in increased stream temperatures or concentrations of nutrients and trace heavy metals that inhibit growth and survival. Sedimentation from landslides following fire or excessive precipitation can also destroy or degrade breeding and rearing habitat.

Like many other amphibians across the globe, Foothill Yellow-legged Frogs are susceptible to the lethal and sublethal effects of disease and pollution. The fungal pathogen *Batrachochytrium dendrobatidis* (Bd) is linked to the greatest recorded loss of biodiversity attributable to a disease and is responsible for dramatic declines and extinctions in hundreds of species of amphibians around the world. Bd is widespread in the environment and likely contributed to the Foothill Yellow-legged Frog's disappearance from southern California and other parts of its range is implicated as the causative factor in two recent mass-mortality events in the Bay Area. As the nation's largest agricultural producer and exporter, tons of agricultural chemicals are applied to California farms annually and can travel substantial distances through the atmosphere. Disappearance and declines in Foothill Yellow-legged Frog populations correlate with proximity and proportion of nearby agriculture. The species is particularly sensitive to some of the commonly used organophosphates, which disrupt nerve impulse transmission. Pesticide exposure can result in direct mortality, immunosuppression, reduced resistance to the parasites that cause limb malformations, decreased growth and activity, and increased vulnerability to predation.

Predation likely contributed, and continues to contribute, to Foothill Yellow-legged Frog population declines, particularly where the habitat is degraded by one or many other risk factors. Predation by and competition with introduced species like American Bullfrogs can have substantial adverse effects; abundance of Foothill Yellow-legged Frogs was nearly an order of magnitude (i.e., 10 times) lower in stream reaches where bullfrogs were well established. Bullfrogs are also asymptomatic carriers of Bd.

Additional threats that can contribute to Foothill Yellow-legged Frog habitat degradation and population declines include mining, livestock grazing, recreational activities, urban and agricultural land use and expansion, cannabis cultivation, timber harvest, and some biological surveys and habitat restoration activities.

Several environmental laws and regulations reduce adverse impacts on Foothill Yellow-legged Frogs. Efforts to avoid, minimize, or mitigate these threats have been incorporated into many environmental impact assessments, regional conservation plans, and permits and licenses. Nevertheless, remaining populations throughout a large portion of the species' California range continue to be small and are losing genetic diversity. Additional actions are needed to conserve and improve existing populations in many areas and to re-establish populations in areas where they have been extirpated.

The scientific information available to the Department indicates that Foothill Yellow-legged Frog faces varying degrees of imperilment throughout its range. The Department recommends that the Commission find that the petitioned action to list Foothill Yellow-legged Frog as threatened is warranted for the Feather River and Northeast/Northern Sierra clades; that the East/Southern Sierra, West/Central Coast, and Southwest/South Coast clades be listed as endangered; and that listing of the Northwest/North Coast clade is not warranted at this time.

1.0 REGULATORY SETTING

1.1 Petition Evaluation Process

A petition to list the Foothill Yellow-legged Frog (*Rana boylii*) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on December 14, 2016 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on December 22, 2016 and published a formal notice of receipt of the petition on January 20, 2017 (Cal. Reg. Notice Register 2017, No. 3-Z, p. 46). A petition to list or delist a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3).

On April 17, 2017, the Department provided the Commission with its evaluation of the petition, "Evaluation of the Petition from the Center For Biological Diversity to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on June 21, 2017 in Smith River, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Foothill Yellow-legged Frog was designated a candidate species on July 7, 2017 (Cal. Reg. Notice Register 2017, No. 27-Z, p. 986).

1.2 Status Review Overview

The Commission's action designating the Foothill Yellow-legged Frog as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 21, 2018 in Sacramento, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

This status review report is not intended to be an exhaustive review of all published scientific literature relevant to the Foothill Yellow-legged Frog; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to the Foothill Yellow-legged Frog. This review is intended to provide the Commission with the most current information on the Foothill Yellow-legged Frog and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The status review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

1.3 Federal Endangered Species Act Review

The Foothill Yellow-legged Frog is currently under review for possible listing as threatened or endangered under the federal Endangered Species Act (ESA) in response to a July 11, 2012 petition submitted by the Center for Biological Diversity. On July 1, 2015, the U.S. Fish and Wildlife Service (USFWS) published its 90-day finding that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted and initiated a status review of the species (USFWS 2015). On March 16, 2016, the Center for Biological Diversity sued the USFWS to compel issuance of a 12-month finding on whether listing under the ESA is warranted. On August 30, 2016, the parties reached a stipulated settlement agreement that the USFWS shall publish its 12-month finding in the Federal Register on or before September 30, 2020 (Center for Biological Diversity v. S.M.R. Jewell (D.D.C. Aug. 30, 2016, No. 16-CV-00503)).

2.0 BIOLOGY AND ECOLOGY

2.1 Species Description and Life History

> *"In its life-history* boylii *exhibits several striking specializations which are in all probability related to the requirements of life of a stream-dwelling species"* – Tracy I. Storer, 1925

The Foothill Yellow-legged Frog is a small- to medium-sized frog; adults range from 1.5 to 3.2 inches snout-to-urostyle length (SUL) with females attaining a larger size than males and males possessing paired internal vocal sacs (Zweifel 1955, Nussbaum et al. 1983, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs are typically gray, brown, olive, or reddish with brown-black flecking and mottling, which generally matches the substrate of the stream in which they reside (Nussbaum et al. 1983, Stebbins and McGinnis 2012). They often have a pale triangle between the eyes and snout and broad dark bars on the hind legs (Zweifel 1955, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs have a relatively squat body and granular skin, giving them a rough appearance similar to a toad, and fully webbed feet with slightly expanded toe tips (Nussbaum et al. 1983). The tympanum is also rough and relatively small compared to other ranids (frogs in the family Ranidae) at around one-half the diameter of the eye (Zweifel 1955). The Foothill Yellow-legged Frog's dorsolateral folds (glandular ridges extending from the eye area to the rump) are indistinct compared to other western North American ranids (Stebbins and McGinnis 2012). Ventrally, the abdomen is white with variable amounts of dark mottling on the chest and throat, which are unique enough to be used to identify individuals (Marlow et al. 2016). As their name suggests, the undersides of their hind limbs and lower abdomen are often yellow; however, individuals with orange and red have been observed within the range of the California Red-legged Frog (*Rana draytonii*), making hindlimb coloration a poor diagnostic characteristic for this species (Jennings and Hayes 2005).

Adult females likely lay one clutch of eggs per year and may breed every year (Storer 1925, Wheeler et al. 2006). Foothill Yellow-legged Frog egg masses resemble a compact cluster of grapes approximately 1.8 to 3.5 inches in diameter lengthwise and contain anywhere from around 100 to over 3,000 eggs (Kupferberg et al. 2009c, Hayes et al. 2016). The individual embryos are dark brown to black with a lighter area at the vegetative pole and surrounded by three jelly envelopes that range in diameter from approximately 0.15 to 0.25 inches (Storer 1925, Zweifel 1955, Hayes et al. 2016).

Foothill Yellow-legged Frog tadpoles hatch out around 0.3 inch long and are a dark brown or black (Storer 1925, Zweifel 1955). They grow rapidly to 1.5 to 2.2 inches and turn olive with a coarse brown mottling above and an opaque silvery color below (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012). Their eyes are positioned dorsally when viewed from above (i.e., within the outline of the head), and their mouths are large, downward-oriented, and suction-like with several tooth rows (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012, Hayes et al. 2016). Foothill Yellow-legged Frogs metamorphose at around 0.55 to 0.67 of an inch SUL (Fellers 2005). Sexual maturity is attained at around 1.2 to 1.6 inches SUL and 1 to 2 years for males and around 1.6 to 2.0 inches SUL and 3 years for females, although in some populations this has been accelerated by a year (Zweifel 1955, Kupferberg et al. 2009c, Breedveld and Ellis 2018). During the breeding season, males can be distinguished from females by the presence of nuptial pads (swollen darkened thumb bases that aid in holding females during amplexus) and calling, which frequently occurs underwater but sometimes from the surface (MacTague and Northen 1993, Stebbins 2003, Silver 2017).

The reported lifespan of Foothill Yellow-legged Frogs varies widely by study. Storer (1925) estimated a maximum age of 2 years for both sexes, and Van Wagner (1996) stated that Foothill Yellow-legged Frogs rarely exceeded 2 years old at his study site. Breedveld and Ellis (2018) calculated the typical lifespan of males at 3-4 years and 5-6 years for females. Bourque (2008), using skeletochronology, found an individual over 7 years old and a mean age of 4.7 and 3.6 years for males and females, respectively. Drennan et al. (2015) estimated maximum age at 13 years for both sexes in a Sierra Nevada population and 12 for males and 11 for females in a Coast Range population.

2.2 Range and Distribution

Based on the current understanding of the Foothill Yellow-legged Frog's historical distribution, which is sparse in many areas, the species likely ranged from the Willamette River drainage in Oregon west of the Sierra-Cascade crest to at least the San Gabriel River drainage in Los Angeles County, California (Zweifel 1955, Nussbaum et al. 1983, Stebbins 2003). In addition, a disjunct population was reported from 6,700 ft in the Sierra San Pedro Mártir, Baja California Norte, México (Loomis 1965). In California, the species has been reported from foothill and mountain streams in the Klamath, Cascade, Sutter

Buttes, Coast, Sierra Nevada, and Transverse ranges from sea level to around 6,000 ft, although Hemphill (1952) describes observing them as high as 6,400 ft at one North Coast location (Stebbins 2003, Olson et al. 2016). Zweifel (1955) considered Foothill Yellow-legged Frogs to be present and abundant throughout their range where streams possessed suitable habitat.

Figure 1 depicts the Department's approximation of the Foothill Yellow-legged Frog's historical range. The majority of the range boundaries in California were taken directly from Thomson et al. (2016) and are used for the Department's California Wildlife Habitat Relationships (CWHR) range. Their methodology included plotting observations in a geographic information system (GIS), intersecting those points with watershed boundaries, developing an approximate range boundary using interpolation between the observations and watershed boundaries, and expert opinion (Ibid.). The Sutter Buttes were added for this report based on Olson et al. (2016). The range in Oregon was based on the species' range map in Nussbaum et al. (1983), and the range in México was estimated from the locality description in Loomis (1965).

As described in more detail below, Foothill Yellow-legged Frog taxonomy has changed many times since originally described, and consequently, some museum specimens collected before the 1960s are erroneous. As stated in the Petition, to date, all recently reevaluated Foothill Yellow-legged Frog-labeled museum specimens south of the San Gabriel mountains in California were determined to be Southern Mountain Yellow-legged Frogs (*Rana muscosa*). No evidence suggests that those not re-evaluated would be reconciled another way. This likely happened in some places in the Sierra Nevada as well, as Foothill Yellow-legged Frogs are rarely found above 5,000 ft (R. Peek pers. comm. 2019a). Based on recent genetics work in the northern Sierra Nevada, all yellow-legged frogs located above 5,000 ft were Sierra Nevada Yellow-legged Frogs (*R. sierrae*) (Bedwell 2018, Peek 2018).

2.3 Taxonomy and Phylogeny

Foothill Yellow-legged Frogs belong to the family Ranidae (true frogs), which inhabits every continent except Antarctica and contains over 400 species (AmphibiaWeb 2019b). The species was first described by Baird (1854) as *Rana boylii*. After substantial taxonomic uncertainty with respect to its relationship to other ranids, several name changes (including the specific epithet spelling of *boylei*), and recognition of three subspecies over the next century, the Foothill Yellow-legged Frog (*R. boylii*) was again recognized as a monotypic species (i.e., without subspecies) by Zweifel (1955, 1968). The phylogenetic relationships among the western North American *Rana* spp. have been revised several times and are still not entirely resolved (Thomson et al. 2016). The Foothill Yellow-legged Frog was previously thought to be most closely related to the higher-elevation Sierra Nevada Yellow-legged Frog and Southern Mountain Yellow-legged Frog (Zweifel 1955; Green 1986a,b; Vredenburg et al. 2007). However, more recent genetic analyses suggest they are most closely related to Columbia Spotted Frogs (*R. luteiventris*) (Macey et al. 2001, Hillis and Wilcox 2005, Yuan et al. 2016).

Figure 1. Estimated historical range of the Foothill Yellow-legged Frog (adapted from Loomis [1965], Nussbaum et al. [1983], Olson et al. 2016, CWHR 2014). See Section 2.2 Range and Distribution for map construction methods and stipulations.

2.4 Population Structure and Genetic Diversity

Genetic divergence among populations and genetic diversity within those populations are critical to species protection. Genetic divergence is a measure of the number of mutations accumulated between population lineages since they last shared a common ancestor. It represents the amount of time that lineages have been separated; the longer the time, the greater the genetic divergence. Given that evolutionary processes, including local adaptation and speciation, tend to accumulate over time, a general principle in conservation genetics is that deeply diverged lineages need to be individually managed and protected to preserve the full evolutionary potential of a species. Molecular genetic/genomic analyses allow one to quantify genetic divergence and clearly delimit the geographic boundaries of populations and the amount of gene flow or isolation among them (McCartney-Melstad and Shaffer 2015). Genetic divergence is often depicted as a phylogenetic tree (see Figure 2), which visually summarizes the evolutionary relationships among populations and taxa (AmphibiaWeb 2019a). A branch on a phylogenetic tree that contains a group of lineages comprised of an ancestor and all its descendants is referred to as a monophyletic group, or a clade (Ibid.). Clades are nested hierarchically in a phylogenetic tree, and effective conservation strategies often identify the "major" clades, which represent populations from the most divergent lineages in that tree, as key management units. These major clades may be sufficiently differentiated into diagnosable species or subspecies, or they may diverge to that point if the evolutionary process continues.

Because the processes that drive genetic divergence among populations and among species are the same (i.e., mutation, natural selection, genetic drift), it can be difficult to determine when populations within species have differentiated enough to suggest they are evolving independently and may be considered separate species or subspecies (Hey and Pinho 2012). Hey and Pinho (2012) examined use of gene flow and separation time measures to distinguish between intraspecific and interspecific differences. The most widely used summary measure of population divergence is the fixation index F_{ST}, a quantitative measure of the proportion of the total genetic variance in a study among populations or lineages. Hey and Pinho's analyses indicated that F_{ST} values greater than 0.35 among lineages correlated best with species designations, while values below 0.35 were more consistent with within-species variation (Ibid.). This population-genetics based approach to estimating genetic divergence can help reveal cryptic diversity within a putative species, and in some cases may lead to the recognition of previously unrecognized species (AmphibiaWeb 2019a).

In contrast to divergence among populations, genetic diversity summarizes variation within a population or lineage, which provides information on population health and indicates the extent to which populations have the capacity to adapt (i.e., evolve) to changing conditions (Hughes et al. 2008). Loss of genetic diversity often signals extreme reductions in population size (genetic bottlenecks) and greatly increases the potential for inbreeding depression that can reduce survival and reproductive success (Lande and Shannon 1996, Frankham 2005, Hoffmann and Sgrò 2011, McCartney-Melstad et al. 2018). Amphibians as a group may be particularly vulnerable to the effects of low genetic diversity; there are several documented instances of reduced fitness as a result of eroded genetic diversity in amphibians that may be contributing to global declines in this taxon (Allentoft and O'Brien 2010).

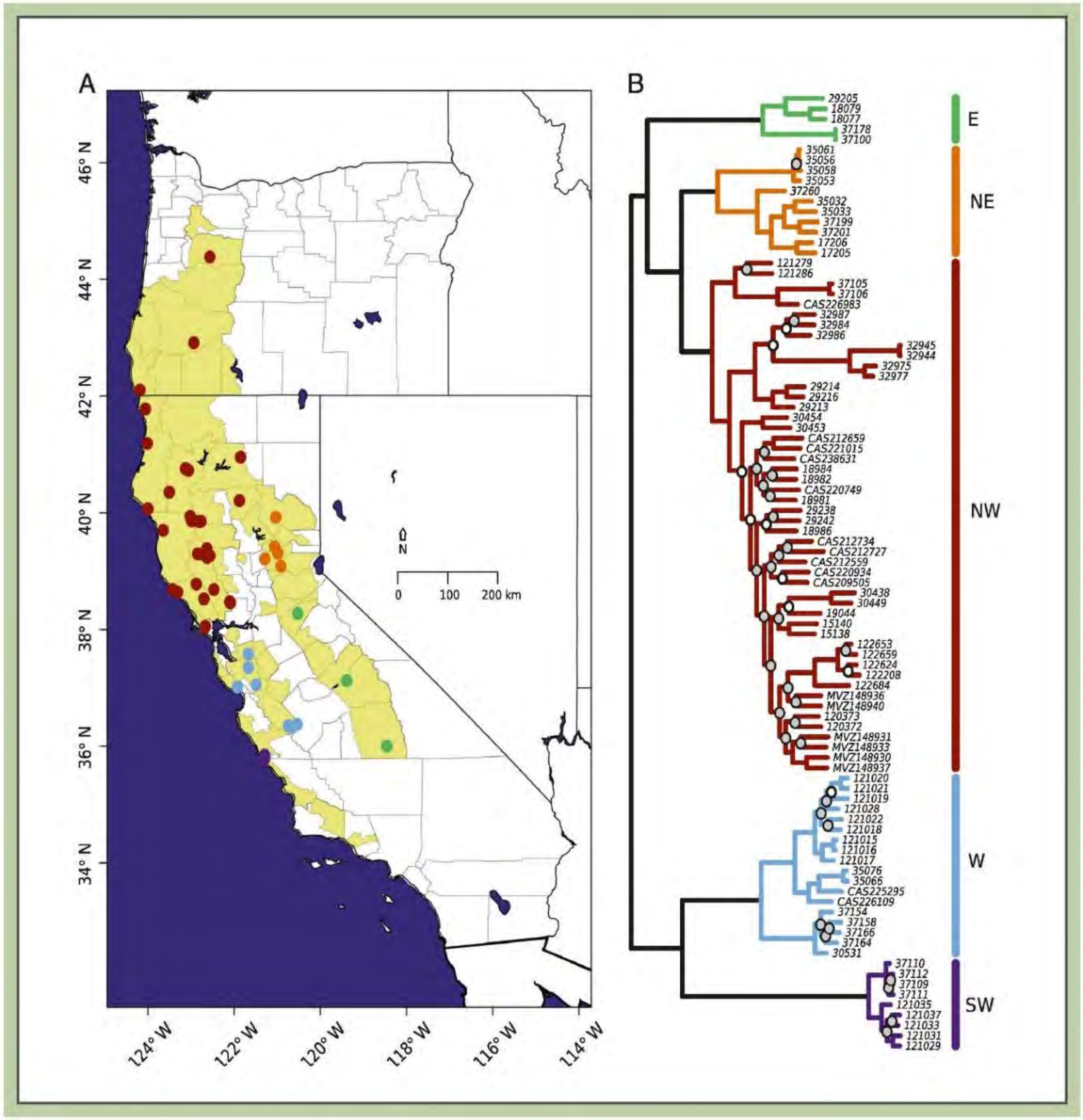

Figure 2. Foothill Yellow-legged Frog clades identified by McCartney-Melstad et al. (2018) Yellow polygons = International Union for Conservation of Nature's range map; colored circles = sampling sites.

Foothill Yellow-legged Frog populations exhibit varying levels of genetic divergence and diversity depending on the spatial scale of comparison. At the coarse scale, comprised of variation across the species' extant range, McCartney-Melstad et al. (2018) recovered five deeply divergent, geographically cohesive, genetic clades from their analyses (Figure 2), while Peek (2018) utilized expanded geographic sampling and recovered six (Figure 3). Both analyzed thousands of genomic loci generated using RADseq approaches. The lowest F_{ST} value McCartney-Melstad et al. (2018) calculated among their five recognized lineages was 0.312 between the Northwest and Northeast clades (see Figure 2 and below for details on estimated clade boundaries), and the highest was 0.794 between the Southwest and East clades. Peek (2018) calculated F_{ST} between pairs of populations across the Foothill Yellow-legged Frog's

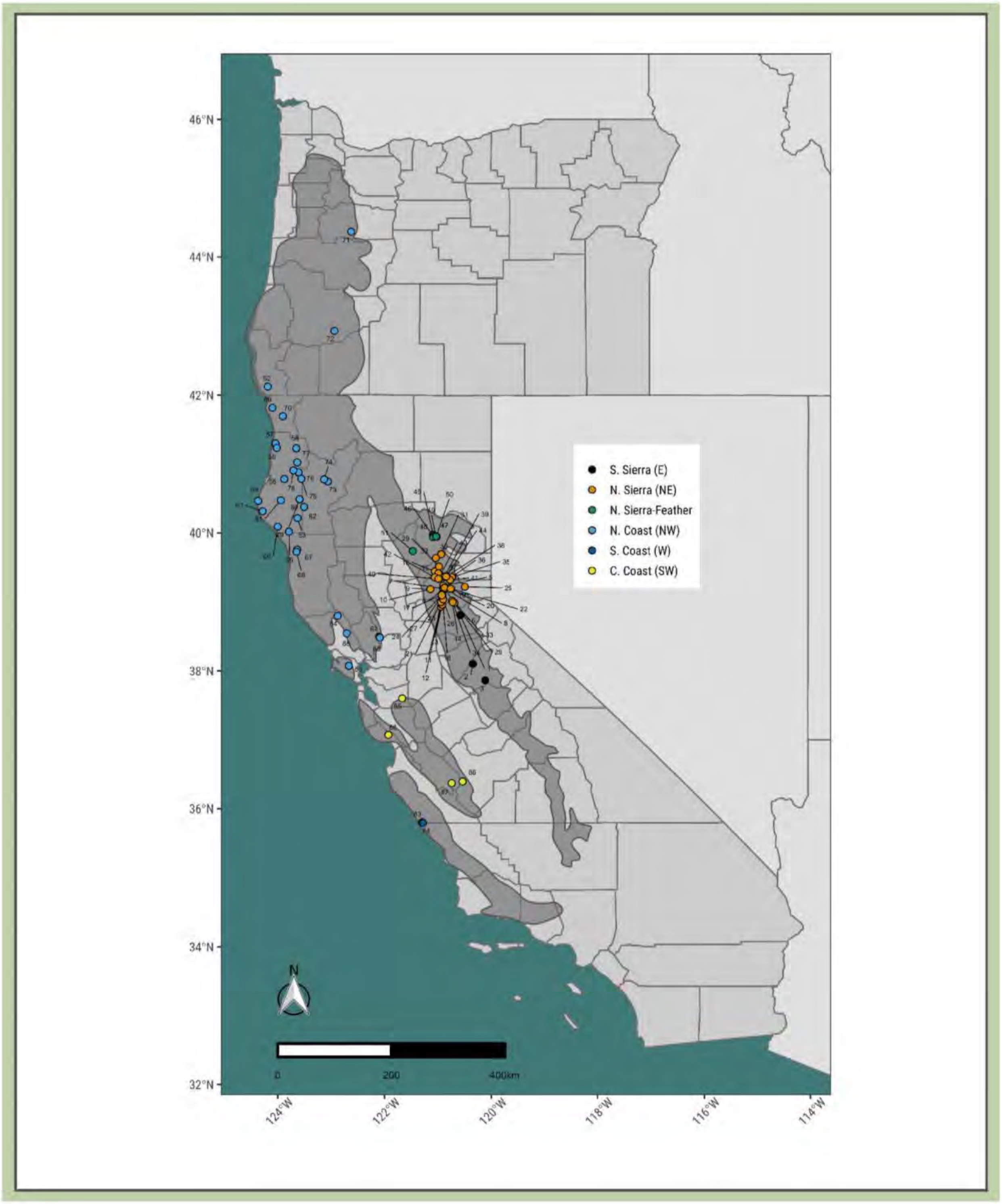

Figure 3. Foothill Yellow-legged Frog clades identified by Peek (2018) Dark gray polygon = presumed range and colored circles and numbers represent specific sampling sites and their clade assignments.

range (1,953 total combinations) and obtained values between 0 and 0.646, with the greatest divergence occurring between the South Coast and Southern Sierra clades (see Figure 3). The results of these two studies, which utilized independent sets of genes and tissues, are virtually identical in recognizing clades and their very high level of divergence (McCartney-Melstad et al. 2018, Peek 2018). These high genetic divergence values indicate that few to no genes have been exchanged between these clades for extended periods of evolutionary time, suggesting a long history of reproductive isolation from each other. These clades represent unique, largely non-overlapping, genetic lineages within the species that are important for the preservation of genetic variation within this wide-ranging species. Additional study may better delineate clade boundaries and suggest that they represent distinct species.

The geographic breaks among the five Foothill Yellow-legged Frog clades were similar between the studies; however, Peek (2018) identified a unique deeply divergent genetic clade in the Feather River watershed that is distinct from the rest of the northern Sierra Nevada clade. The five clades common to both studies include the following [Note: naming conventions follow McCartney-Melstad et al. (2018) and Peek (2018)]:

(1) Northwest/North Coast: north of San Francisco Bay in the Coast Ranges and east into Tehama County;

(2) Northeast/Northern Sierra: northern El Dorado County (North Fork American River watershed, includes Middle Fork American River) and north in the Sierra Nevada to southern Plumas County (Upper Yuba River watershed);

(3) East/Southern Sierra: El Dorado County (South Fork American River watershed) and south in the Sierra Nevada [no samples from Amador County were tested, but they would most likely fall within this clade because it is located between two other populations that occur within this clade];

(4) West/Central Coast: south of San Francisco Bay in the Coast Ranges to San Benito and Monterey counties, presumably east of the San Andreas Fault/Salinas Valley; and

(5) Southwest/South Coast presumably west of the San Andreas Fault/Salinas Valley in Monterey County and south in the Coast Ranges.

The Feather River clade is found primarily in Plumas and Butte counties (Peek 2018). Peek's analysis found that this clade is as distinct from the other Sierra Nevada clades as the Sierra Nevada populations are from all coastal clades, meaning it was found to be deeply divergent from the rest of the clades. McCartney-Melstad et al. (2018) also recognized the Feather River watershed as distinct from the rest of the northern Sierra but not as deeply divergent from the other clades as Peek. The Feather River watershed is also the only known location where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs co-occur and where three F1 hybrids (the offspring from a cross between parents of the two species) were found (Peek 2018, R. Peek pers. comm. 2019b). In addition, Peek's (2018) genetic data provided weak support for dividing the West/Central Coast and Southwest/South Coast groups into separate clades; however, his data set consisted of fewer samples from these localities than McCartney-Melstad et al. (2018).

Previous work conducted by Lind et al. (2011), using one nuclear and two mitochondrial genes, found a somewhat similar pattern, and their results suggested that hydrologic regions and river basins were important landscape features that influenced the genetic structure of Foothill Yellow-legged Frog populations. McCartney-Melstad et al. (2018), using a much larger genomic data set with thousands of genes rather than just three, also found evidence for divergence among river basins. However, they also found nearly twice the variation among the five phylogenetic clades than among drainage basins, indicating that other geological factors in addition to current riverine basins contributed to current population structure (Ibid.). They also report that the depth of genetic divergence among Foothill Yellow-legged Frog clades exceeds that of any frog or toad species for which similar data are available on earth and recommend treating them as key management units instead of the previously suggested watershed boundaries (Ibid.). Peek (2018) concurred and stated that the Foothill Yellow-legged Frog clades represented important units that should be carefully considered during planning and implementation of conservation actions.

Levels of genetic diversity within the clades differed significantly. Genetic diversity provides populations with the evolutionary capacity to adapt to changing conditions (i.e., evolve), and its loss often signals extreme population size reductions, which can result in genetic bottlenecks and inbreeding depression that can reduce survival and reproductive success (Lande and Shannon 1996, Hoffmann and Sgrò 2011, McCartney-Melstad et al. 2018). Loss of genetic diversity in Foothill Yellow-legged Frogs largely follows a north-to-south pattern, with the southern clades (Southwest/South Coast and East/Southern Sierra) particularly exhibiting the greatest loss of nucleotide diversity (McCartney-Melstad et al. 2018, Peek 2018). In addition, these study results demonstrate that Foothill Yellow-legged Frogs have lost genetic diversity over time across their entire range except for the large Northwest/North Coast clade, which appears to have undergone a relatively recent population expansion (McCartney-Melstad et al. 2018, Peek 2018).

At a watershed scale, Dever (2007) found that tributaries to rivers and streams are important for preserving genetic diversity, and populations separated by more than 6.2 mi show signs of genetic isolation. In other words, even in the absence of anthropogenic barriers to dispersal (e.g., dams and reservoirs), individuals located more than 6.2 mi are not typically considered part of a single interbreeding population (Olson and Davis 2009). Peek (2010, 2018) reported that at this finer-scale, population structure and genetic diversity appear to be more strongly influenced by river regulation type (i.e., dammed or undammed) than to geographic distance or watershed boundaries. In general, regulated (dammed) rivers had limited gene flow and higher genetic divergence among subpopulations compared with unregulated (undammed) rivers (Peek 2010, 2018). In addition, differences in hydrologic regimes within regulated rivers affected genetic connectivity and diversity (Peek 2010, 2018). Subpopulations in hydropeaking reaches, in which pulsed flows are used for electricity generation or whitewater boating, exhibited significantly lower gene flow and genetic diversity than those in bypass reaches where water is diverted from upstream in the basin down to power generating facilities (Figure 4; Peek 2018, R. Peek pers. comm. 2019b). River regulation had a greater influence on genetic

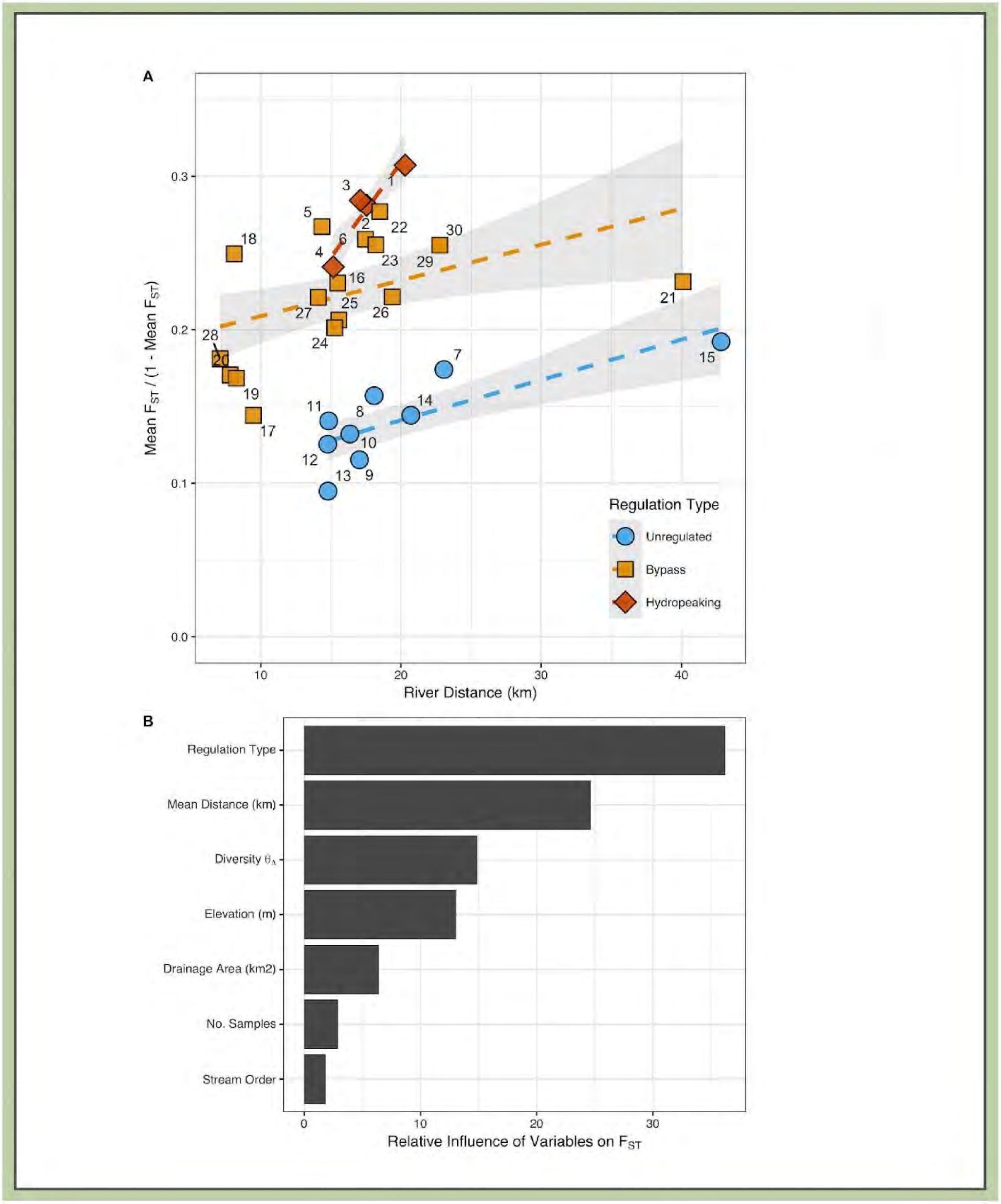

Figure 4. River regulation's relative influence on genetic differentiation from Peek (2018). A) Mean pairwise F_{ST} vs. mean river distance for each location (denoted by unique numbers); B) Relative influence of variables on F_{ST} from boosted regression tree models.

differentiation among sites than geographic distance in the Alameda Creek watershed as well (Stillwater Sciences 2012). Reduced connectivity among sites leads to lower gene flow and a loss of genetic diversity through genetic drift, which can diminish adaptability to changing environmental conditions (Palstra and Ruzzante 2008). Peek (2010) posits that given the *R. boylii* species group is estimated to be 8 million years old (Macey et al. 2001), the significant reductions in connectivity and genetic diversity over short evolutionary time periods in regulated rivers (often less than 50 years from the time of dam construction) is cause for concern with respect to population viability and persistence, particularly when combined with small population sizes.

2.5 Habitat Associations and Use

> *"These frogs are so closely restricted to streams that it is unusual to find one at a greater distance from the water than it could cover in one or two leaps."* – Richard G. Zweifel, 1955

Foothill Yellow-legged Frogs inhabit rivers and streams ranging from primarily rain-fed (coastal populations) to primarily snow-influenced (most Sierra Nevada and Klamath-Cascade populations) from headwater streams to large rivers (Bury and Sisk 1997, Wheeler et al. 2014). Occupied rivers and streams flow through a variety of vegetation types including hardwood, conifer, and valley-foothill riparian forests; mixed chaparral; and wet meadows (Hayes et al. 2016). Because the species is so widespread and can be found in so many types of habitats, the vegetation community is likely less important in determining Foothill Yellow-legged Frog occupancy and abundance than the aquatic biotic and abiotic conditions in the specific river, stream, or reach (Zweifel 1955). The species is an obligate stream-breeder, which sets it apart from other western North American ranids (Wheeler et al. 2014). Foothill Yellow-legged Frog habitat is generally characterized as partly-shaded, shallow, perennial rivers and streams with a low gradient and rocky substrate that is at least cobble-sized (Zweifel 1955, Hayes and Jennings 1988). However, the use of intermittent and ephemeral streams by post-metamorphic Foothill Yellow-legged Frogs may not be all that uncommon in some parts of the species' range in California (R. Bourque pers. comm. 2019). The species has been reported from some atypical habitats as well, including small impoundments, isolated pools in intermittent streams, and meadows along the edge of streams that lack a rocky substrate (Fitch 1938, Zweifel 1955, CDFW 2018a, Wilcox and Alvarez 2019). In addition, Wilcox and Alvarez (2019) described observations of Foothill Yellow-legged Frogs climbing a vertical, but undulating, dam wall covered in algae, suggesting that landscape features like steep, slick rock slopes may not preclude movement.

As stream-breeding poikilotherms (animals whose internal temperature varies with ambient temperature), appropriate flow velocity, temperature, and water availability are critically important to Foothill Yellow-legged Frogs (Kupferberg 1996a, Van Wagner 1996, Wheeler et al. 2006, Lind et al. 2016, Bedwell 2018). Habitat quality is also influenced by hydrologic regime (regulated vs. unregulated), substrate, presence of non-native predators and competitors, water depth, and availability of high-quality food and basking sites (Lind et al. 1996, Yarnell 2005, Wheeler et al. 2006, Catenazzi and Kupferberg 2017). Habitat suitability and use vary by life stage, sex, geographic location, watershed size, and season and can generally be categorized as breeding and rearing habitat, nonbreeding season habitat, and overwintering habitat (Van Wagner 1996, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011, Hayes et al. 2016, Catenazzi and Kupferberg 2017). Yarnell (2005) located higher densities of Foothill Yellow-legged Frogs in areas with greater habitat heterogeneity and suggested that they were selecting sites that possessed the diversity of habitats necessary to support each life stage within a relatively short distance.

2.5.1 Breeding and Rearing Habitat

Suitable breeding habitat must be connected to suitable rearing habitat for metamorphosis to be successful. When this connectivity exists, as flows decline through the season, tadpoles can follow the receding shoreline into areas of high productivity and lower predation risk as opposed to becoming trapped in isolated pools with a high risk of overheating, desiccation, and predation (Kupferberg et al. 2009c).

Several studies on Foothill Yellow-legged Frog breeding habitat, carried out across the species' range in California, reported similar findings. Foothill Yellow-legged Frogs select oviposition (egg-laying) sites within a narrow range of depths, velocities, and substrates and exhibit fidelity to breeding sites that consistently possess suitable microhabitat characteristics over time (Kupferberg 1996a, Bondi et al. 2013, Lind et al. 2016). At a coarse-spatial scale, breeding sites in rivers and large streams are often located near the confluence of tributary streams in sunny, wide, shallow reaches (Kupferberg 1996a, Yarnell 2005, GANDA 2008, Peek 2010). These areas are highly productive compared to cooler, deeper, closed-canopy sites (Catenazzi and Kupferberg 2013). At a fine spatial scale, females prefer to lay eggs in low velocity areas dominated by cobble- and boulder-sized substrates, often associated with sparsely-vegetated point bars (Kupferberg 1996a, Lind et al. 1996, Van Wagner 1996, Bondi et al. 2013, Lind et al. 2016). They tend to select areas with less variable, more stable flows, and in areas with higher flows at the time of oviposition, they place their eggs on the downstream side of large cobblestones and boulders, which protects them from being washed away (Kupferberg 1996a, Wheeler et al. 2006).

Appropriate rearing temperatures are vital for successful metamorphosis. Tadpoles grow faster and larger in warmer water to a point (Zweifel 1955; Catenazzi and Kupferberg 2017,2018). Zweifel (1955) conducted experiments on embryonic thermal tolerance and determined that the critical low was approximately 43°F, and the critical high was around 79°F. Welsh and Hodgson (2011) determined that best the single variable for predicting Foothill Yellow-legged Frog presence was temperature since none were observed below 55°F, but numbers increased significantly with increasing temperature. Catenazzi and Kupferberg (2013) measured tadpole thermal preference at 61.7-72.0°F, and the distribution of Foothill Yellow-legged Frog populations across a watershed was consistent within this temperature range. When the daily average temperatures during the warmest month of the year were below 61°F, tadpoles were absent under closed canopy and scarce even with an open canopy (Ibid.). Catenazzi and Kupferberg (2017) found regional differences in apparently suitable breeding temperatures. Inland populations from primarily snowmelt-fed systems with relatively cold water were relegated to reaches that are warmer on average during the warmest 30 days of the year than coastal populations in the chiefly rainfall-fed, and thus warmer, systems (63.7-75.6°F vs. 60.3-71.6°F, respectively). However, experiments on tadpole thermal preference demonstrated that individuals from different source populations selected similar rearing temperatures, which presumably optimized development (Ibid.). In regulated systems, where water released from dams is often colder than normal, suitable rearing temperatures downstream may be limited (Wheeler et al. 2014, Catenazzi and Kupferberg 2017).

Appropriate flow velocities are also critical for survival to metamorphosis. The velocity at which Foothill Yellow-legged Frog egg masses shear away from the substrate they are adhered to varies according to factors such as depth and degree to which the eggs are sheltered (Spring Rivers Ecological Sciences 2003). This critical velocity is expected to decrease as the egg mass ages due to the reduced structural integrity of the protective jelly envelopes (Hayes et al. 2016). Short duration increases in flow velocity may be tolerated if the egg masses are somewhat protected, but sustained high velocities increase the likelihood of detachment (Kupferberg 1996a, Spring Rivers Ecological Sciences 2003). Hatchlings and tadpoles about to undergo metamorphosis are relatively poor swimmers and require especially slow, stable flows during these stages of development (Kupferberg et al. 2011b). Tadpoles respond to increasing flows by swimming against the current to maintain position for a short period of time and eventually swimming to the bottom and seeking refuge in the rocky substrate's interstitial spaces (Ibid.). When tadpoles are exposed to repeated increases in velocities, their growth and development are delayed (Ibid.). Under experimental conditions, the critical velocity at which tadpoles were swept downstream ranged between 0.66-1.31 ft/s; however, as they reach metamorphosis it decreases to as low as 0.33 ft/s (Ibid.).

2.5.2 Nonbreeding Season Habitat

Post-metamorphic Foothill Yellow-legged Frogs utilize a more diverse range of habitats and are much more dispersed during the nonbreeding season than the breeding season. Microhabitat preferences appear to vary by location and season, but some patterns are common across the species' range. Foothill Yellow-legged Frogs tend to remain close to the water's edge (average <10 ft); select sunny areas with limited canopy cover; and are often associated with riffles and pools (Zweifel 1955, Hayes and Jennings 1988, Van Wagner 1996, Welsh et al. 2005, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011). Adequate water, food resources, cover from predators, ability to thermoregulate (e.g., presence of basking sites and cool refugia), and absence of non-native predators are important components of nonbreeding season habitat (Hayes and Jennings 1988, Van Wagner 1996, Catenazzi and Kupferberg 2013).

2.5.3 Overwintering Habitat

Overwintering habitat varies depending on local conditions, but as with the rest of the year, Foothill Yellow-legged Frogs are most often found in or near water where they can forage and take cover from predators and high discharge events (Storer 1925, Zweifel 1955). In larger streams and rivers, Foothill Yellow-legged Frogs are often found along tributaries during the winter where the risk of being displaced by heavy flows is reduced (Kupferberg 1996a, Gonsolin 2010). Bourque (2008) found 36.4% of adult females used intermittent and ephemeral tributaries during the overwintering season. Van Wagner (1996) located most overwintering Foothill Yellow-legged Frogs using pools with cover such as boulders, root wads, and woody debris. During high flow events, they moved to the stream's edge and took cover under vegetation like sedges (*Carex* sp.) or leaf litter (Ibid.). Rombough (2006) found most

Foothill Yellow-legged Frogs under woody debris along the high waterline and often using seeps along the stream-edge, which provided them with moisture, a thermally stable environment, and prey.

Exceptions to the pattern of remaining near the stream's edge during winter have been reported. Cook et al. (2012) observed dozens of juvenile Foothill Yellow-legged Frogs traveling over land, as opposed to using riparian corridors. They were found using upland habitats with an average distance of 234 ft from water (range: 52-1,086 ft) (Ibid.). In another example, a single subadult that was found adjacent to a large wetland complex 2,723 ft straight-line distance from the wetted edge of the Van Duzen River, although it is possible the wetland was connected to the river via a spillway or drainage that may have served as the movement corridor (CDFW 2018a, R. Bourque pers. comm. 2019).

2.5.4 Seasonal Activity and Movements

Because Foothill Yellow-legged Frogs occupy areas with relatively mild winter temperatures, they can be active year-round, although at low temperatures (<44°F), they become lethargic (Storer 1925, Zweifel 1955, Van Wagner 1996, Bourque 2008). They are active both day and night, and during the day adults are often observed basking on warm objects such as sun-heated rocks, although this is also when their detectability is highest (Fellers 2005, Wheeler et al. 2005). For example, Gonsolin (2010) located radio-telemetered Foothill Yellow-legged Frogs under substrate a third of the time and underwater a quarter of the time, but nearly all his detections of frogs without transmitters were basking.

Adult Foothill Yellow-legged Frogs migrate from their overwintering sites to breeding habitat in the spring, often from a tributary to its confluence with a larger stream or river. In areas where tributaries dry down, juveniles also make this downstream movement (Haggarty 2006). When the tributary itself is perennial and provides suitable breeding habitat, the frogs may not undertake these long-distance movements (Gonsolin 2010). Cues for adults to initiate this migration to breeding sites are somewhat enigmatic and vary by location, elevation, and amount of precipitation (S. Kupferberg and A. Lind pers. comm. 2017). They can include day length, water temperature, and sex (GANDA 2008, Gonsolin 2010, Yarnell et al. 2010, Wheeler et al. 2018). Males initiate movements to breeding sites where they congregate in leks (areas of aggregation for courtship displays), and females arrive later and over a longer period (Wheeler and Welsh 2008, Gonsolin 2010). Most males utilize breeding sites associated with their overwintering tributaries, but some move substantial distances to other sites and may use more than one breeding site in the same season (Wheeler et al. 2006, GANDA 2008).

While the predictable hydrograph in California consists of wet winters with high spring flows and dry summers with low flows, the timing and quantity of seasonal discharge can vary significantly from year to year. The timing of oviposition can influence offspring growth and survival. Early breeders risk scouring of egg masses from their substrate by late spring storms in wet years or desiccation if waters recede rapidly, but when they successfully hatch, tadpoles benefit from a longer growing season, which can enable them to metamorphose at a larger size and increase their likelihood of survival (Railsback et al. 2016). Later breeders are less likely to have their eggs scoured away or desiccated because flows are generally more stable, but they have fewer mate choices, and their tadpoles have a shorter growing period before metamorphosis, reducing their chance of survival (Ibid.). Some evidence indicates larger females, who coincidentally lay larger clutches, breed earlier (Kupferberg et al. 2009c, Gonsolin 2010). Consequently, early season scouring or stranding of egg masses or tadpoles can disproportionately impact the population's reproductive output because later breeders produce fewer and smaller eggs per clutch (Kupferberg et al. 2009c, Gonsolin 2010).

Timing of oviposition is often a function of water temperature and flow, but it consistently occurs on the descending limb of the hydrograph, which is the period of time when high spring discharge gradually recedes toward low summer base flow (Kupferberg 1996a, GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010, Yarnell et al. 2010, Yarnell et al. 2013). Under natural conditions, the timing coincides with intermittent tributaries drying down and increases in algal blooms that provide forage for tadpoles (Haggarty 2006, Power et al. 2008). Even in regulated systems, hydrodynamic modeling indicated that managing for flow recessions with down-ramping rates similar to those observed in unregulated systems (less than 10% per day) provided the most diverse hydraulic habitat for an appropriate duration in spring to support native species and maximize aquatic biodiversity (Yarnell et al. 2013). At lower elevations, breeding can start in late March or early April, and at mid-elevations, breeding typically occurs in mid-May to mid-June (Gonsolin 2010, S. Kupferberg and A. Lind pers. comm. 2017). The time of year a population initiates breeding can vary by as much as two months among water years, occurring later at deeper sites when colder water becomes warmer (Wheeler et al. 2018, R. Peek pers. comm. 2019a). In wetter years, delayed breeding into early July can occur in some colder snowmelt systems (Yarnell et al. 2013, GANDA 2018).

A population's period of oviposition can also vary from two weeks to three months, meaning they could be considered explosive breeders at some sites and prolonged breeders at others (Storer 1925, Zweifel 1955, Van Wagner 1996, Ashton et al. 1997, Wheeler and Welsh 2008). Water temperature typically warms to over 50°F before breeding commences (GANDA 2008, Gonsolin 2010, Wheeler et al. 2018). Wheeler and Welsh (2008) observed Foothill Yellow-legged Frogs breeding when flows were below 02 ft/s, pausing during increased flows until they receded, and GANDA (2008) reported breeding initiated when flow decreased to less than 55% above base flow.

Male Foothill Yellow-legged Frogs spend more time at breeding sites during the season than females, many of whom leave immediately after laying their eggs (GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010). Daily movements are usually short (<1 ft), but some individuals travel substantial distances: median 232 ft/day in spring and 104 ft/day in fall/winter, nearly always using streams as movement corridors (Van Wagner 1996, Bourque 2008, Gonsolin 2010). The maximum reported movement rate is 0.86 mi/day, and the longest seasonal (post-breeding) daily distance reported is 4.37 mi by a female that traveled up a dry tributary and over a ridge before returning to and moving up the mainstem creek (Bourque 2008). Movements during the non-breeding season are typically in response to drying channels or during rain events (Bourque 2008, Gonsolin 2010, Cook et al. 2012).

Hatchling Foothill Yellow-legged Frogs tend to remain with what is left of the egg mass for several days before dispersing into the interstitial spaces in the substrate (Ashton et al. 1997). They often move downstream in areas of moderate flow and will follow the location of warm water in the channel throughout the day (Brattstrom 1962, Ashton et al. 1997, Kupferberg et al. 2011a). Tadpoles usually

metamorphose in late August or early September (S. Kupferberg and A. Lind pers. comm. 2017). Twitty et al. (1967) reported that newly metamorphosed Foothill Yellow-legged Frogs mostly migrated upstream, which may be an evolutionary mechanism to return to their natal site after being washed downstream (Ashton et al. 1997).

2.5.5 Home Range and Territoriality

Foothill Yellow-legged Frogs exhibit a lek-type mating system in which males aggregate at the breeding site and establish calling territories (Wheeler and Welsh 2008, Bondi et al. 2013). The species has a relatively large calling repertoire for western North American ranids with seven unique vocalizations recorded (Silver 2017). Some of these can be reasonably attributed to territory defense and mate attraction communications (MacTeague and Northen 1993, Silver 2017). Physical aggression among males during the breeding season has been reported (Rombough and Hayes 2007, Wheeler and Welsh 2008, Wilcox and Alvarez 2019). In addition, Wheeler and Welsh (2008) observed a non-random mating pattern in which males engaged in amplexus with females were larger than males never seen in amplexus, suggesting either physical competition or female preference for larger individuals. Very little information has been published on Foothill Yellow-legged Frog home range size. Wheeler and Welsh (2008) studied males during a 17-day period during breeding season and classified some of them as "site faithful" based on their movements and calculated their home ranges. Two-thirds of males tracked were site faithful, and their mean home range size was 6.24 ft^2 (SE = 1.08 ft^2) (Ibid.). In contrast, perhaps because the study took place over a longer time period, Bourque (2008) reported approximately half of the males he tracked during the spring were mobile, and the other half were sedentary. The median distances traveled along the creek (a proxy for home range size since they rarely leave the riparian corridor) for mobile and sedentary males were 489 ft and 18 ft, respectively.

2.6 Diet and Predators

Foothill Yellow-legged Frog diet varies by life stage and likely body size. Tadpoles graze on periphyton (algae growing on submerged surfaces) scraped from rocks and vegetation and grow faster, and to a larger size, when it contains a greater proportion of epiphytic diatoms with nitrogen-fixing endosymbionts (*Epithemia* spp.), which are high in protein and fat (Kupferberg 1997b, Fellers 2005, Hayes et al. 2016, Catenazzi and Kupferberg 2017). Tadpoles may also forage on necrotic tissue from dead bivalves and other tadpoles, or more likely the algae growing on them (Ashton et al. 1997, Hayes et al. 2016). Post-metamorphic Foothill Yellow-legged Frogs primarily feed on a wide variety of terrestrial arthropods but also some aquatic invertebrates (Fitch 1936, Van Wagner 1996, Haggarty 2006). Most of their diet consists of insects and arachnids (Van Wagner 1996, Haggarty 2006, Hothem et al. 2009). Haggarty (2006) did not identify any preferred taxonomic groups, but she noted larger Foothill Yellow-legged Frogs consumed a greater proportion of large prey items compared to smaller individuals, suggesting the species may be gape-limited generalist predators. Hothem et al. (2009) found mammal hair and bones in a Foothill Yellow-legged Frog stomach. Adult Foothill Yellow-legged Frogs, like many other ranids, also cannibalize conspecifics (Wiseman and Bettaso 2007). In the fall when young-of-year are abundant, they may provide an important source of nutrition for adults prior to overwintering (Ibid.).

Foothill Yellow-legged Frogs are preyed upon by several native and introduced species, including each other as described above. Some predators target specific life stages, while others may consume multiple stages. Several species of gartersnakes (genus *Thamnophis*) are the primary and most widespread group of native predators on Foothill Yellow-legged Frog tadpoles through adults (Fitch 1941, Fox 1952, Zweifel 1955, Lind and Welsh 1994, Ashton et al. 1997, Wiseman and Bettaso 2007, Gonsolin 2010). Table 1 lists other known and suspected predators of Foothill Yellow-legged Frogs.

3.0 STATUS AND TRENDS IN CALIFORNIA

3.1 Administrative Status

3.1.1 Sensitive Species

The Foothill Yellow-legged Frog is listed as a Sensitive Species by the U.S. Bureau of Land Management (BLM) and USDA Forest Service (Forest Service). These agencies define Sensitive Species as those species that require special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA.

3.1.2 California Species of Special Concern

The Department's Species of Special Concern (SSC) designation is similar to the federal Sensitive Species designation. It is administrative, rather than regulatory in nature, and intended to focus attention on animals at conservation risk. The designation is used to stimulate needed research on poorly known species and to target the conservation and recovery of these animals before they meet the CESA criteria for listing as threatened or endangered (Thomson et al. 2016). The Foothill Yellow-legged Frog is listed as a Priority 1 (highest risk) SSC (Ibid.).

3.2 Trends in Distribution and Abundance

3.2.1 Range-wide in California

Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551). Historical documentation of Foothill Yellow-legged Frog distribution and abundance is somewhat haphazard. However, systematic range-wide assessments of Foothill Yellow-legged Frog distribution were conducted relatively recently. Estimates of relative abundance or population trends are less common at both local and range-wide scales. This makes assessing trends in distribution and abundance difficult despite a relatively large number of observations compared to many other species tracked by the California Natural Diversity Database (CNDDB). A detailed account of what has been documented within the National Parks and National Forests in California can be found in Appendix 3 of the *Foothill Yellow-legged Frogs Conservation Assessment in California* (Hayes et al. 2016). The CNDDB contained 2,411 Foothill Yellow-legged Frog occurrences in its August 2019 edition, at least 529 (22%) of which were observed in 2014 or more recently.

Table 1. Confirmed and potential Foothill Yellow-legged Frog predators in California in addition to gartersnakes (*Thamnophis* spp.)

Common Name	Scientific Name	Classification	Native	Prey Life Stage(s)	Sources
Caddisfly (larva)	*Dicosmoecus gilvipes*	Insect	Yes	Embryos (eggs)	Rombough and Hayes 2005
Dragonfly (nymph)	*Aeshna walker*	Insect	Yes	Larvae	Catenazzi and Kupferberg 2018
Waterscorpion	*Ranatra brevicollis*	Insect	Yes	Larvae	Catenaazi and Kupferberg 2018
Signal Crayfish	*Pacifastacus leniusculus*	Crustacean	No	Embryos (eggs) and Larvae	Rombough and Hayes 2005; Wiseman et al. 2005
Speckled Dace	*Rhinichthys osculus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Reticulate Sculpin	*Cottus perplexus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Sacramento Pikeminnow	*Ptychocheilus grandis*	Fish	Yes*	Embryos (eggs) to Adults	Corum 2003; Ashton and Nakamoto 2007
Sunfishes	Family Centrachidae	Fish	No	Larvae	Moyle 1973; Hayes and Jennings 1986
Catfishes	Family Ictaluridae	Fish	No	Larvae	Moyle 1973; Hayes and Jennings 1986
Rough-skinned Newt	*Taricha granulosa*	Amphibian	Yes	Embryos (eggs)	Evenden 1948
California Giant Salamander	*Dicamptodon ensatus*	Amphibian	Yes	Larvae	Fidenci 2006
American Bullfrog	*Rana catesbeiana*	Amphibian	No	Larvae to Adults	Crayon 1998; Hothem et al. 2009
California Red-legged Frog	*Rana draytonii*	Amphibian	Yes	Larvae to Adults	Gonsolin 2010
American Robin	*Turdus migratorius*	Bird	Yes	Larvae	Gonsolin 2010
Common Merganser	*Mergus merganser*	Bird	Yes	Larvae	Gonsolin 2010
American Dipper	*Cinclus mexicanus*	Bird	Yes	Larvae	Ashton et al. 1997
Mallard	*Anas platyrhynchos*	Bird	Yes	Adults	Rombough et al. 2005
Raccoon	*Procyon lotor*	Mammal	Yes	Larvae to Adults	Zweifel 1955; Ashton et al. 1997
River Otter	*Lontra canadensis*	Mammal	Yes	Larvae to Adults	S. Kupferberg pers. comm. 2019; T. Rose pers. comm. 2014

* Introduced to the Eel River, location of documented predation; Foothill Yellow-legged Frogs are extirpated from most areas of historical range overlap

A few wide-ranging historical survey efforts that included Foothill Yellow-legged Frogs exist. Reports from early naturalists suggest Foothill Yellow-legged Frogs were relatively common in the Coast Ranges as far south as central Monterey County, in eastern Tehama County, and in the foothills in and near Yosemite National Park (Grinnell and Storer 1924, Storer 1925, Grinnell et al. 1930, Martin 1940). In addition to these areas, relatively large numbers of Foothill Yellow-legged Frogs (17-35 individuals) were collected at sites in the central and southern Sierra Nevada and the San Gabriel Mountains between 1911 and 1950 (Hayes et al. 2016). Widespread disappearances of Foothill Yellow-legged Frog populations were documented as early as the 1970s and 80s in southern California, the southern Coast Range, and the central and southern Sierra Nevada foothills (Moyle 1973, Sweet 1983).

Twenty-five years ago, the Department published the first edition of *Amphibians and Reptile Species of Special Concern in California* (Jennings and Hayes 1994). The authors revisited hundreds of localities between 1988 and 1991 that had historically been occupied by Foothill Yellow-legged Frogs and consulted local experts to determine presumed extant or extirpated status. Based on these survey results and stressors observed on the landscape, they considered Foothill Yellow-legged Frogs endangered in central and southern California south of the Salinas River in Monterey County. They considered the species threatened in the west slope drainages of the Cascade Mountains and Sierra Nevada east of the Central Valley, and they considered the remainder of the range to be of special concern (Ibid.).

Fellers (2005) and his field crews conducted surveys for Foothill Yellow-legged Frogs throughout California. They visited 804 sites across 40 counties with suitable habitat within the species' historical range. They detected at least one individual at 213 sites (26.5% of those surveyed) over 28 counties. They located Foothill Yellow-legged Frogs in approximately 40% of streams in the North Coast, 30% in the Cascade Mountains and south of San Francisco in the Coast Range, and 12% in the Sierra Nevada. Fellers estimated population abundance was 20 or more adults at only 14% of the sites where the species was found and noted the largest and most robust populations occurred along the North Coast. In addition, to determine status of Foothill Yellow-legged Frogs across the species' range and potential causes for declines between 2000 and 2002, Lind (2005) used previously published status accounts, species expert and local biologist professional opinions, and field visits to historically occupied sites. She determined that Foothill Yellow-legged Frogs had disappeared from 201 of 394 of the sites, representing just over 50%. The coarse-scale trend of Foothill Yellow-legged Frog populations in California is one of greater declines and extirpations in lower elevations and latitudes (Davidson et al. 2002).

Few site-specific population trend data are available from which to evaluate status. However, some long-term monitoring efforts have used egg mass counts as a proxy to estimate adult breeding female abundance. The results of these studies revealed extreme interannual variability in number of egg masses laid (Ashton et al. 2010, S. Kupferberg and M. Power pers. comm. 2015, Peek and Kupferberg 2016). In a meta-analysis of egg mass count data collected across the species' range in California over the past 25 years, Peek and Kupferberg (2016) reported declines in two unregulated rivers and an increase in another. Their models did not detect any significant trends in abundance across different locations or regulation type (dammed or undammed); however, high interannual variability can render trend detection difficult. Interannual variability was substantially greater in regulated rivers vs.

unregulated; the median coefficients of variation were 66.9% and 41.6%, respectively (Ibid.). The greater variability in regulated rivers decreases the probability of identifying significant declines, and coupled with low abundance, it can lead to populations dropping below a density necessary for persistence undetected, resulting in extirpation.

Regional differences in Foothill Yellow-legged Frog persistence across its range have been recognized for nearly 50 years (i.e., more extirpations documented in the south than other parts of the range). Because of these differences and the recent availability of new landscape genomic data, more detailed descriptions of trends in Foothill Yellow-legged Frog population distribution and abundance in California are evaluated by clade below. Figure 5 depicts Foothill Yellow-legged Frog localities across all clades in California by the most recent confirmed sighting in the datasets available to the Department within a Public Land Survey System (PLSS) section. "Transition Zones" are those areas where the exact clade boundaries are unknown due to a lack of samples. In addition, while not depicted as an area of uncertainty, no genetic samples have been evaluated from south of the extant population in northern San Luis Obispo County, in the Sutter Buttes in Sutter County, or northeastern Plumas County. It is possible there were historically more clades than is currently understood. For management purposes and the Department's listing recommendation using the best available science, clade boundaries were delineated along commonly recognized geographic features like county lines, watershed subbasin (HU8) boundaries, and anthropogenic linear features that coincide as closely as possible with what is known about Foothill Yellow-legged Frog genetic population structure (Figure 6).

Caution should be exercised in comparing the following observation data across the species' range and across time since survey effort and reporting are not standardized. These data can be useful for making some general inferences about distribution, abundance, and trends. For instance, the species was present at a location at least as recently as the date of the record, assuming the species was correctly identified. However, this only works in the affirmative. For example, at a site where the last time the species was seen was 75 years ago, the species may continue to persist there if no one surveyed it adequately since the original observation. CNDDB staff use information on land use conversion, subsequent survey results, and biological reports to categorize an occurrence location as "extirpated" or "possibly extirpated".

3.2.2 Northwest/North Coast Clade

The current known range of Northwest/North Coast clade extends from north of San Francisco Bay through the Coast Range and Klamath Mountains to the northern limit of the Foothill Yellow-legged Frog's range and east through the Cascade Range. For management purposes and the Department's listing recommendation, and based on the best available science, the boundaries of the Northwest/North Coast clade include the following whole counties: Colusa, Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Napa, Shasta, Solano, Sonoma, Tehama, Trinity, and Yolo. Portions of Butte, Lassen, Modoc, and Siskiyou counties are also included in this clade and are delineated by the following watershed subbasins: Applegate, Big-Chico Creek-Sacramento, Lower Klamath, Lower Pit, McCloud, Sacramento Headwaters, Salmon, Scott, Shasta, and Upper Klamath (Figure 6). This clade covers the largest geographic area and contains the greatest amount of genetic diversity

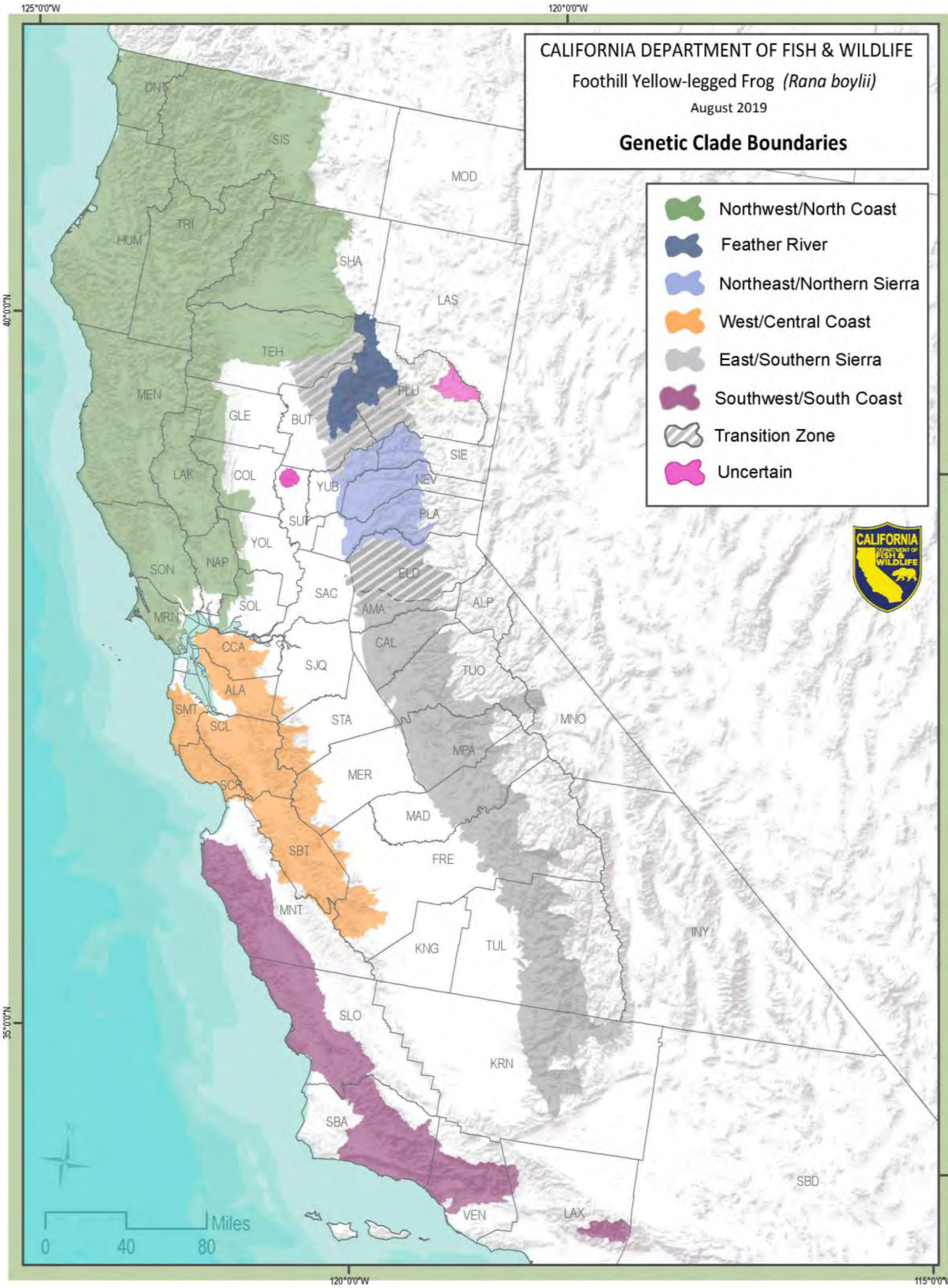

Figure 5. California Foothill Yellow-legged Frog occurrences from 1889-2019 overlaying the species' range and clade boundaries by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

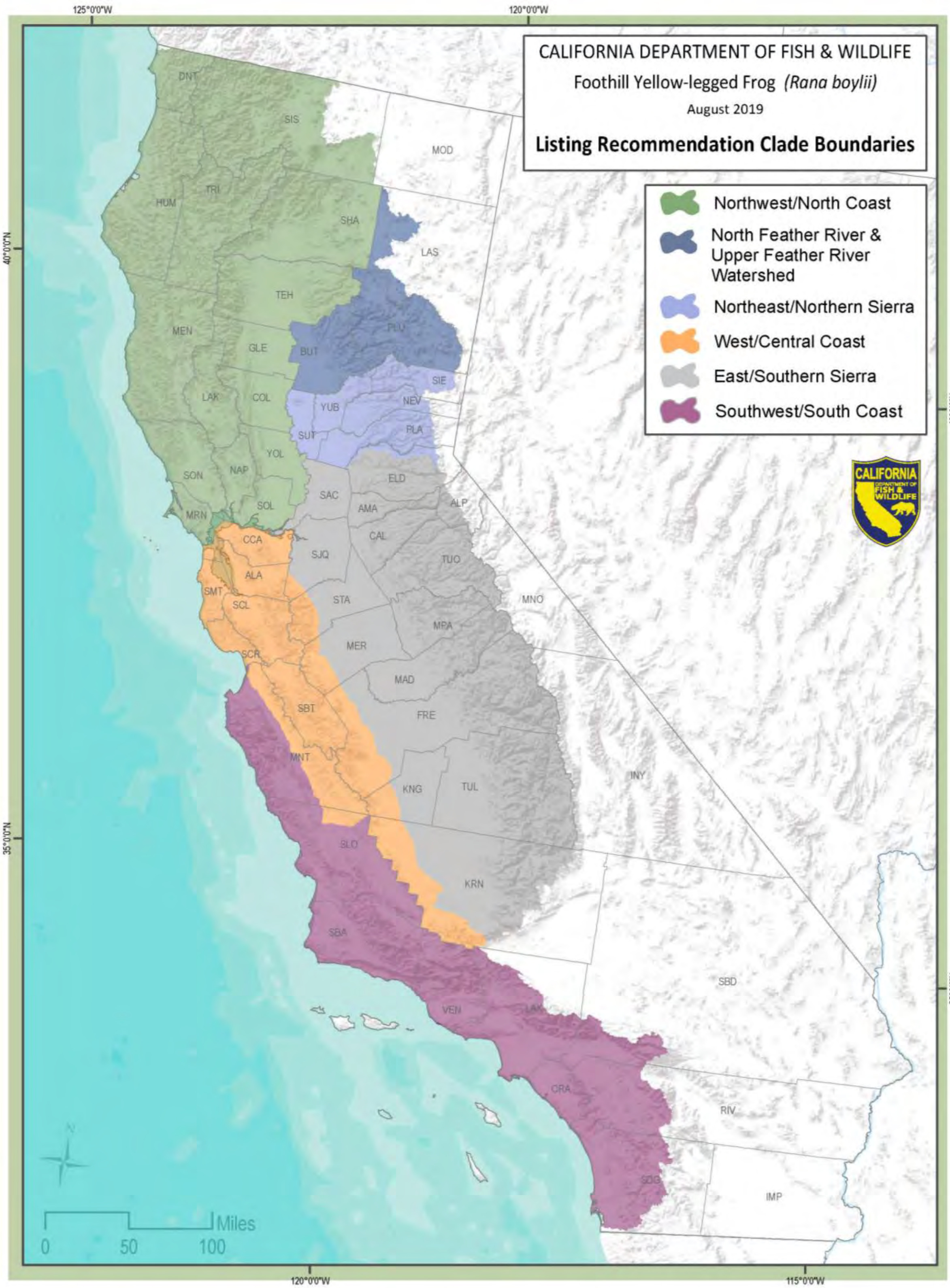

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Figure 6. Foothill Yellow-legged Frog clade boundaries for management purposes and the Department's listing recommendation

(McCartney-Melstad et al. 2018, Peek 2018). In addition, it is the only clade with an increasing trend in genetic diversity (Peek 2018).

Early records note the comparatively high abundance of Foothill Yellow-legged Frogs in this area. Storer (1925) described Foothill Yellow-legged Frogs as very common in many of Coast Range streams north of San Francisco Bay, and Cope (1879,1883 as cited in Hayes et al. 2016) noted they were “rather abundant in the mountainous regions of northern California.” In addition, relatively large collections occurred over short periods of time in this region in the late 1800s and the first half of the 20th century (Hayes et al. 2016). Nineteen were taken over two weeks in 1893 along Orrs Creek, a tributary to the Russian River, and 40 from near Willits (both in Mendocino County) in 1911; 112 were collected over three days at Skaggs Spring (Sonoma County) in 1911; 57 were taken in one day along Lagunitas Creek (Marin County) in 1928; and 50 were collected in one day near Denny (Trinity County) in 1955 (Ibid.).

A few long-term Foothill Yellow-legged Frog egg mass monitoring efforts undertaken within this clade’s boundaries found densities vary significantly, often based on river regulation type, and documented several robust populations. The Green Diamond Resources Company has monitored a stretch of the Mad River near Blue Lake (Humboldt County) since 2008 (GDRC 2018). The greatest published density of Foothill Yellow-legged Frog egg masses was documented here in 2009 at 520.7 egg masses/mi (Bourque and Bettaso 2011). However, in 2017, surveyors counted 1,006 egg masses/mi along the same reach (GDRC 2018). At its lowest during this period, egg mass density was calculated at 115.1/mi in 2010, although this count occurred after a flooding even that likely scoured over half of the egg masses laid that season (GDRC 2018, R. Bourque pers. comm. 2019). During a single day survey in 2017 along approximately 1.3 mi of Redwood Creek in Redwood National Park (Humboldt County), 2,009 young and 126 adult Foothill Yellow-legged Frogs were found (D. Anderson pers. comm. 2017). Some reaches of the South Fork Eel River (Mendocino County) also support high densities of Foothill Yellow-legged Frogs. Kupferberg (pers. comm. 2018) recorded 333 and 171 egg masses/mi along two stretches in 2016, and 324 and 189 egg masses/mi in 2017. However, other reaches yielded counts as low as 9.8 and 13.5 egg masses/mi (Ibid.). In the Angelo Reserve (an unregulated reach), the 24-year mean density was 175.4/mi (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015). In contrast, a 10-year mean density of egg masses below Lewiston Dam on the Trinity River (Trinity County) was 1.43/mi (Ibid.).

Figure 7 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, Biological Information Observation System (BIOS) datasets, and personal communications that are color coded by the most recent date of detection. Nearly 65% of Foothill Yellow-legged Frog CNDDB records (1,558) occur within this clade, and recent observations (2014 and later) were made in at least 366 areas (CNDDB 2019). The species remains widespread within many watersheds, although most observations only verify presence, or fewer than ten individuals or egg masses are recorded (Ibid.). Documented extirpations are comparatively rare (Figure 8), and nearly all occurred just north of the high-populated San Francisco Bay area (Ibid.).

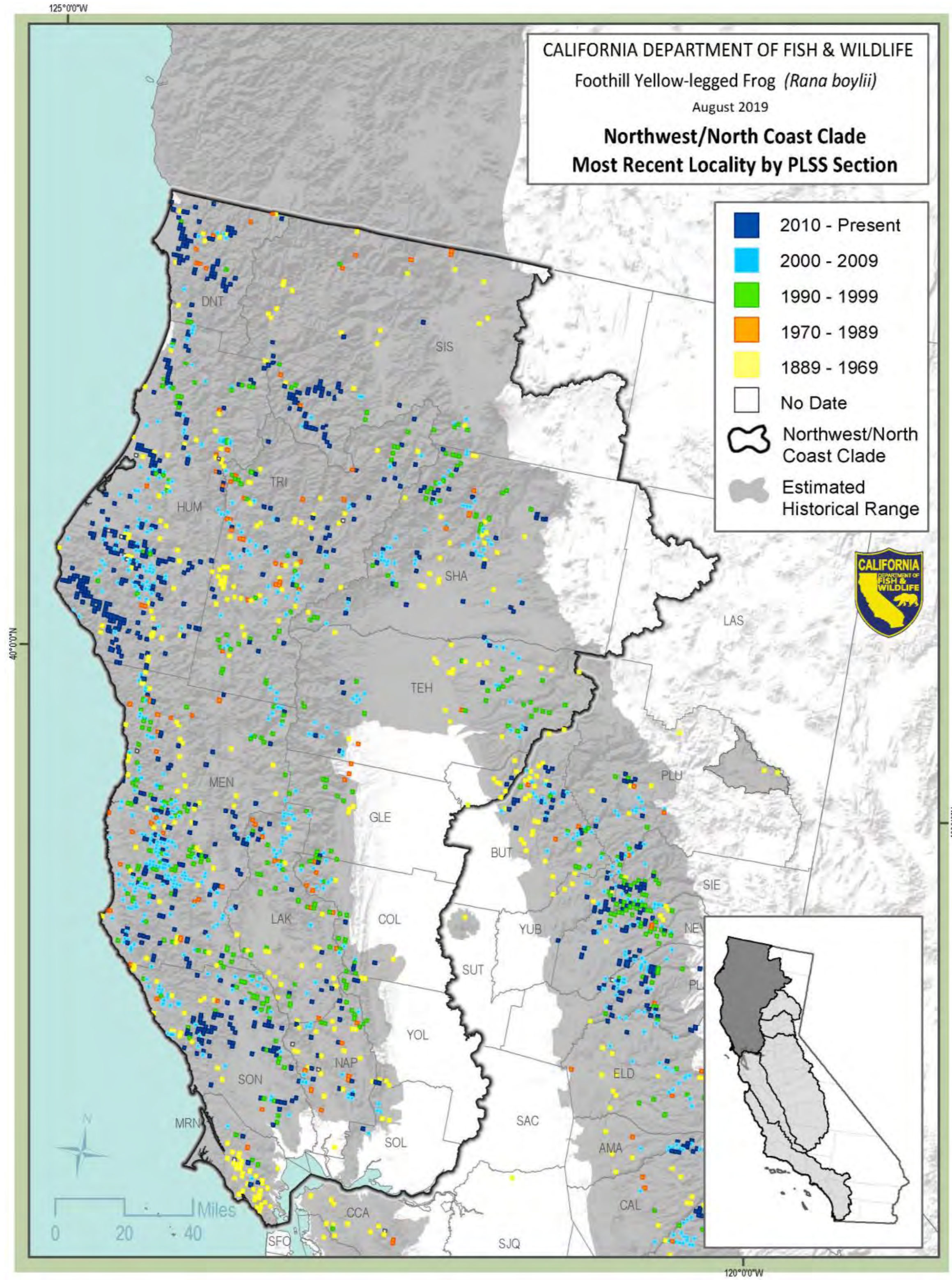


Figure 7. Northwest/North Coast Foothill Yellow-legged Frog clade observations from 1889-2019 by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

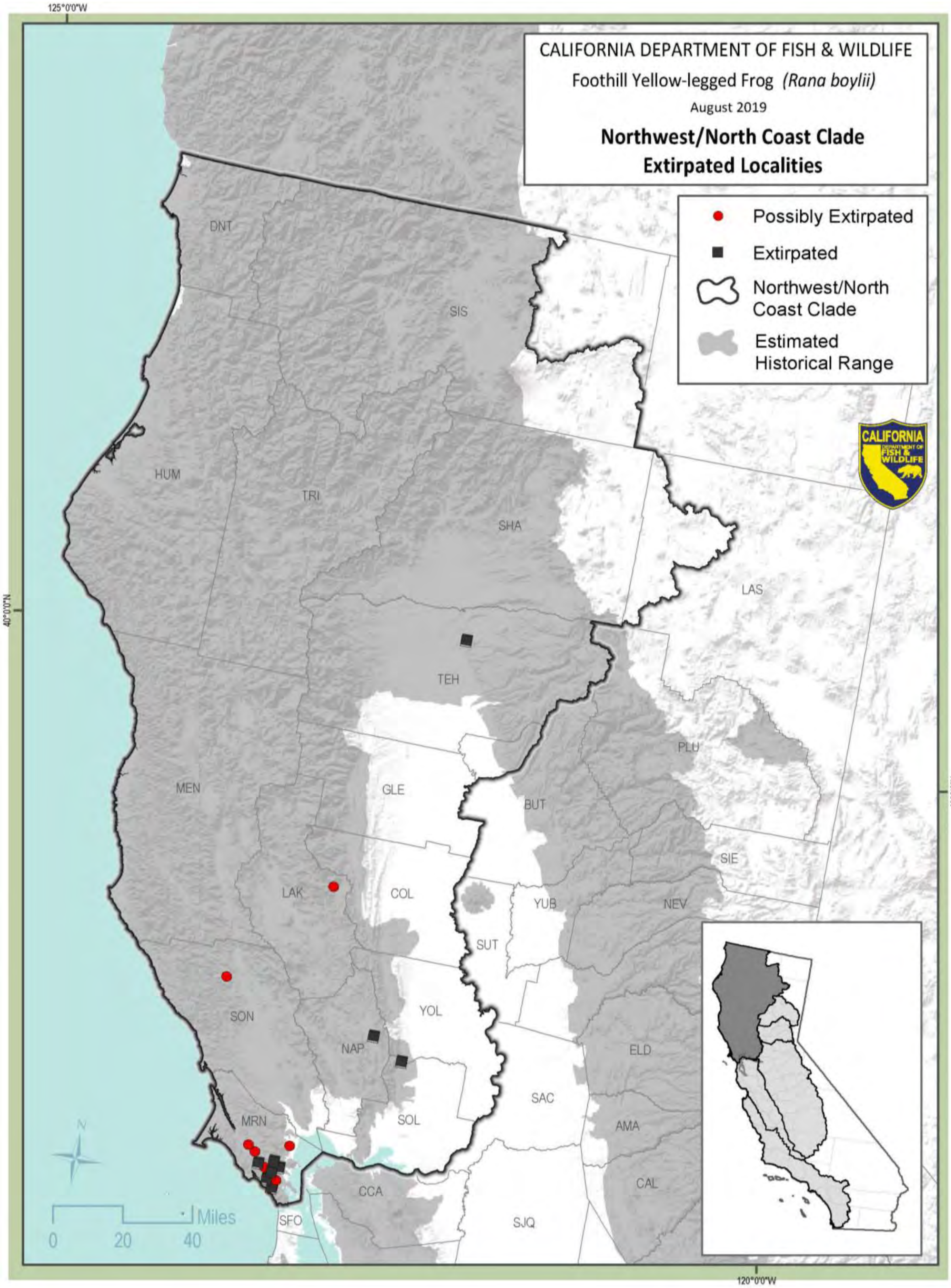


Figure 8. Possibly extirpated and extirpated Northwest/North Coast Foothill Yellow-legged Frog clade occurrences (CNDDB)

3.2.3 Feather River Clade

The Feather River clade was included in the Northeast clade as defined by McCartney-Melstad et al. (2018), but according to Peek (2018), it is very distinct and located primarily in Plumas and Butte counties. No genetic samples were available for testing from the disjunct population in northeastern Plumas County before it was extirpated. If these were correctly identified Foothill Yellow-legged Frogs, as opposed to Sierra Nevada Yellow-legged Frogs, they may have belonged to a separate clade. However, for management purposes and the Department's listing recommendation, and based on the best available science, the boundaries of the Feather River clade include the following subbasins in Butte, Lassen, Plumas, and Sierra counties: Butte Creek, East Branch of North Fork Feather, Honcut Headwaters-Lower Feather, Middle Fork Feather, and North Fork Feather (Figure 6).

In general, there is a paucity of historical Foothill Yellow-legged Frog data for west-slope Sierra Nevada streams, particularly in the lower elevations of the Sacramento Valley, and no quantitative abundance data exist prior to major changes in the landscape (i.e., mining, dams, and diversions) or the introduction of non-native species (Hayes et al. 2016). Foothill Yellow-legged Frogs were collected frequently from the Plumas National Forest area in small numbers from the turn of the 20th century through the 1970s (Ibid.). Estimates of relative abundance are not clear from the records, but they suggest the species was somewhat widespread in this area.

More recently, Foothill Yellow-legged Frog populations in the Sierra Nevada have been the subject of a focused surveys and research associated with relicensing of hydropower generating dams by the Federal Energy Regulatory Commission (FERC). Foothill Yellow-legged Frogs have been observed in at least 110 locations within this clade, 24 (22%) of which were in 2014 or later (CNDDB 2019). As with the rest of the range, most records are observations of only a few individuals; however, many observations occurred over multiple years, and in some cases all life stages were observed over multiple years (Ibid). The populations appear to persist even with the small numbers reported. Figure 9 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, BIOS, and personal communications that are color coded by the most recent date of detection. Documented extirpations are shown in Figure 10 and occur in lower elevation sites closer to the Sacramento Valley (Ibid.).

The only long-term consistent survey effort in this area has been occurring on the North Fork Feather River along the Cresta and Poe reaches (GANDA 2018). The Cresta reach's subpopulation declined significantly in 2006 and never recovered despite modification of the flow regime to reduce egg mass and tadpole scouring and some habitat restoration (Ibid.). A pilot project to augment the Cresta reach's subpopulation through in situ captive rearing was initiated in 2017 (Dillingham et al. 2018). It resulted in the highest number of young-of-year Foothill Yellow-legged Frogs recorded during fall surveys since researchers started keeping count (Ibid.). The number of egg masses laid in the Poe reach varies substantially year-to-year, from a low of 26 in 2001 to a high of 154 in 2015 and back down to 36 in 2017 (GANDA 2018).

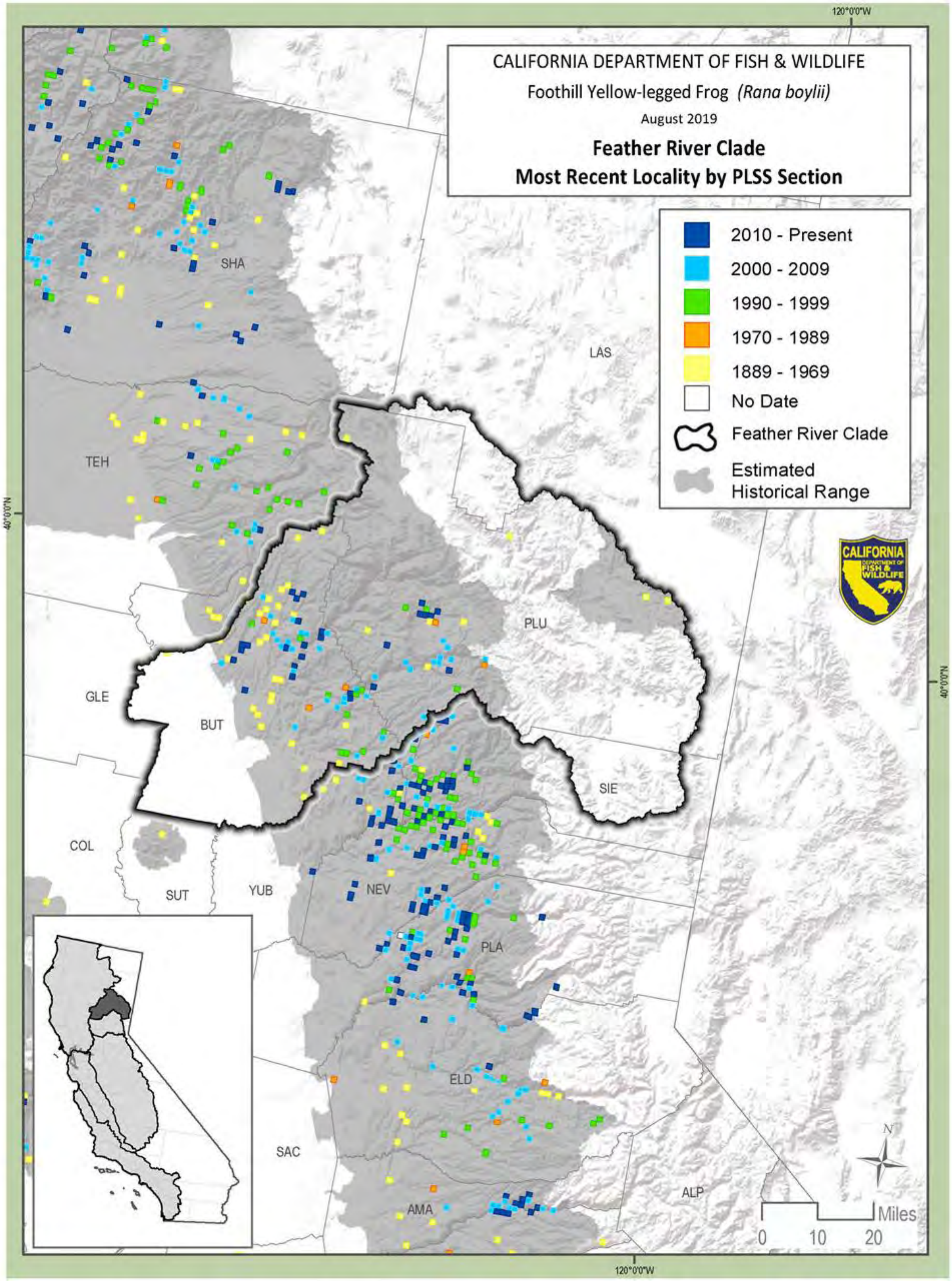


Figure 9. Feather River Foothill Yellow-legged Frog clade observations from 1889-2019 by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

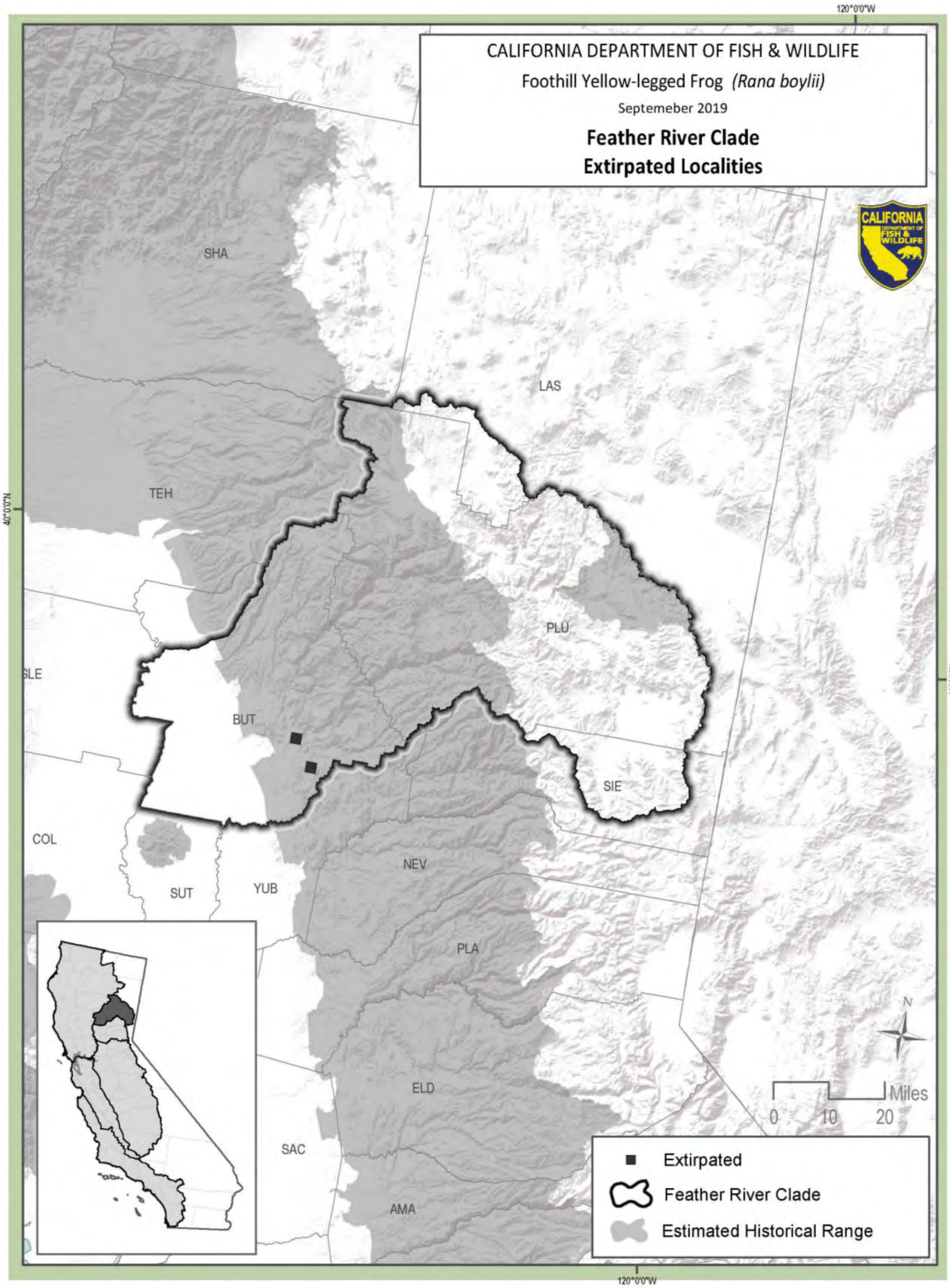


Figure 10. Extirpated Feather River Foothill Yellow-legged Frog clade occurrences (CNDDB)

3.2.4 Northeast/Northern Sierra Clade

The current known range of the Northeast/Northern Sierra clade roughly extends from the Upper Yuba Subbasin south through the North Fork American River Subbasin. No genetic samples were available to test in the Sutter Buttes to determine which clade it belonged to before it was extirpated (Figure 5; Olson et al. 2016). However, for management purposes and the Department's listing recommendation, and based on the best available science, the boundaries of the Northeast/Northern Sierra clade include Sutter County and the following watershed subbasins in Nevada, Placer, Sierra, and Yuba counties: Lower American, North Fork American, Upper Bear, Upper Coon-Upper Auburn, and Upper Yuba (Figure 6).

As described above, little historical data exist for the Foothill Yellow-legged Frog's distribution along west-slope Sierra Nevada streams, and no abundance data exist prior to major changes in the landscape. Foothill Yellow-legged Frogs have been observed in at least 231 locations within this clade, 76 (33%) of which were in 2014 or later (CNDDB 2019). The general pattern in this clade, and across the range, is that unregulated rivers or reaches have more areas that are occupied more consistently over time and in larger numbers than regulated rivers or reaches (CNDDB 2019, S. Kupferberg pers. comm. 2019).

Foothill Yellow-legged Frogs were rarely observed in the hydropeaking reach of the Middle Fork American River and were observed in low numbers in the bypass reach, but they were present and breeding in small tributary populations (PCWA 2008). Relatively robust populations appear to inhabit the North Fork American River and Lower Rubicon River, both in Placer County (Gaos and Bogan 2001, PCWA 2008, Hogan and Zuber 2012, K. Kundargi pers. comm. 2014, S. Kupferberg pers. comm. 2019). Additional apparently sufficiently large and relatively stable populations occur on Clear Creek, South Fork Greenhorn Creek, and Shady Creek (Nevada County) and the North and Middle Yuba River (Sierra County), but the remaining observations are of small numbers in tributaries with minimal connectivity among them (CNDDB 2019, S. Kupferberg pers. comm. 2019).

Figure 11 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, BIOS, and personal communications that are color coded by the most recent date of detection. Only one extirpation has been documented within this clade (Figure 12), but due to the lack of distribution data on the species prior to the Gold Rush in this area, there were undoubtedly others (CNDDB 2019).

3.2.5 East/Southern Sierra Clade

The current known range of the East/Southern Sierra clade extends from the South Fork American River Subbasin (the northernmost area where individuals from this clade were sampled) south to where the Sierra Nevada meets the Tehachapi Mountains. The Central Valley is not considered suitable habitat, and specimens collected from the Mokelumne River in northern San Joaquin County were likely waifs that washed down in a flood (CNDDB 2019). Because some of the San Joaquin Valley counties span both this clade and the West/Central Coast clade, the California Aqueduct was selected as geographic boundary between the two (Figure 6). This is an imperfect boundary because some east-draining creeks from the Coast Range flow into the San Joaquin Valley under the aqueduct. Therefore, for management

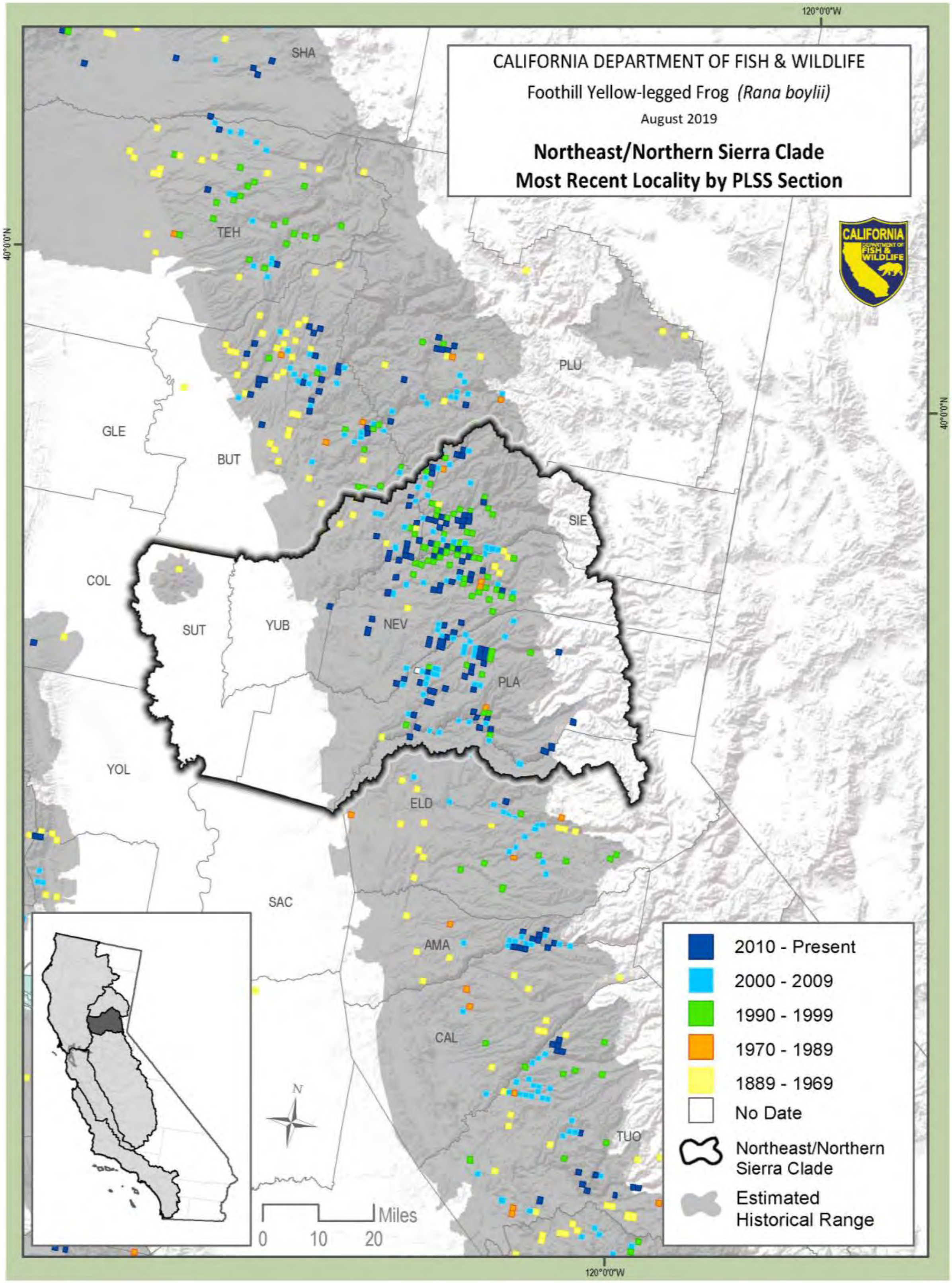


Figure 11. Northeast/Northern Sierra clades observations from 1889-2019 by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CNDDB)

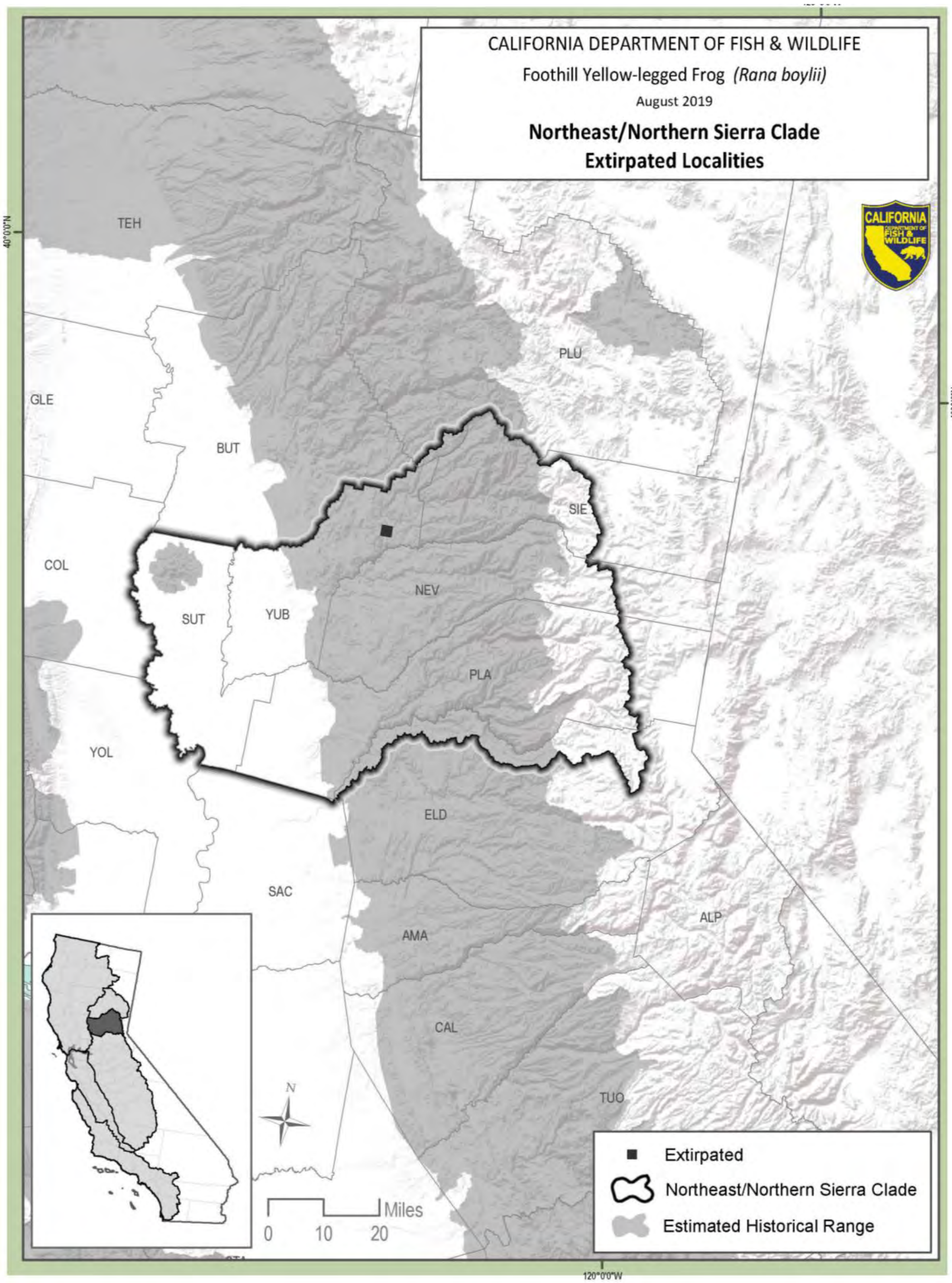


Figure 12. Extirpated Northeast/Northern Sierra Foothill Yellow-legged Frog clades occurrences (CNDDB)

purposes and the Department's listing recommendation, and based on the best available science, the boundaries of the East/Southern Sierra clade include the following whole counties: Amador, Calaveras, Madera, Mariposa, Sacramento, Tulare, and Tuolumne. The portion of Kern County within this clade is bounded on the west by the California Aqueduct and by the following subbasins in the east: Middle Kern-Upper Tehachapi-Grapevine, South Fork Kern, and Upper Kern. The following subbasins in El Dorado and Alpine counties are included in this clade: South Fork American, Upper Cosumnes, and Upper Mokelumne. A small area where the estimated historical range spans into Mono County is also included in this clade. The following counties east of the California Aqueduct are included in this clade: Fresno, Kings, Merced, San Joaquin, and Stanislaus.

Historical collections of small numbers of Foothill Yellow-legged Frogs occurred in every major river system within this clade beginning as early as the turn of the 20th century, indicating widespread distribution, but little information on abundance exists (Hayes et al. 2016). By the early 1970s, declines in Foothill Yellow-legged Frog populations from this area were already apparent; Moyle (1973) found them at 30 of 95 sites surveyed in 1970. Notably bullfrogs inhabited the other 65 sites formerly occupied by Foothill Yellow-legged Frogs, and they co-occurred at only three sites (Ibid.). In 1992, Drost and Fellers (1996) revisited the sites around Yosemite National Park (Tuolumne and Mariposa counties) that Grinnell and Storer (1924) surveyed in 1915 and 1919. Foothill Yellow-legged Frogs had disappeared from all seven historically occupied sites and were not found at any new sites surveyed surrounding the park (Ibid.). Resurveys of previously occupied (pre-1990) sites on the Stanislaus (Tuolumne County), Sierra (Fresno County), and Sequoia (Tulare County) National Forests, six sites per forest, were also undertaken (Lind et al. 2003b). Two of the previously occupied sites on the Stanislaus were still occupied, and 19 new populations were found with evidence of breeding at seven of them (Ibid.). Foothill Yellow-legged Frogs were absent from all of the previously occupied sites in Sierra National Forest, but one new population discovered (Ibid.) Similarly, Foothill Yellow-legged Frogs were absent from all of the previously occupied sites in the Sequoia National Forest, but two new populations were discovered (Ibid.). These populations remain extant but are small and isolated (CNDDB 2019). Twenty of the 24 populations extant at the time inhabited unregulated waterways (Ibid.). Most of the CNDDB (2019) records of Foothill Yellow-legged Frogs on the Stanislaus are at least a decade old and are represented by low numbers.

More recently, surveys for Foothill Yellow-legged Frogs were conducted along the South Fork American River as part of the El Dorado Hydroelectric Project's FERC license amphibian monitoring requirements (GANDA 2017). Between 2002 and 2016, counts of different life stages varied significantly by year, but the trend for every life stage was a decline over that period (Ibid.). Foothill Yellow-legged Frogs have been observed in at least 260 locations within this clade, 34 (13%) of which were in 2014 or later (CNDDB 2019). There appears to be a small population persisting along the North Fork Mokelumne River (Amador and Calaveras counties), but it was only productive during the 2012-2014 drought years (Ibid.). Small numbers have also been observed recently in several locations on private timberlands in Tuolumne County (CNDDB 2019).

Figure 13 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, BIOS, and personal communications that are color coded by the most recent date of detection. The proportion of extirpated sites in this clade is second only to the Southwest/South Coast and follows the pattern of greater losses in the south (Figure 14). Like the southern coastal clade, the southern Sierra clade has low genetic variability and a trajectory of continued loss of diversity (Peek 2018).

3.2.6 West/Central Coast Clade

The current known range of the West/Central Coast clade extends south from the San Francisco Bay through the Diablo Range and down the peninsula through the Santa Cruz and Gabilan Mountains in the Coast Range east of the Salinas Valley. No Foothill Yellow-legged Frogs belonging to this clade are expected south of Monterey and Fresno counties (Figure 5), and whether the species ever occurred in San Francisco County is unknown. For management purposes and the Department's listing recommendation, and based on the best available science, the West/Central Coast clade includes the following whole counties: Alameda, Contra Costa, San Benito, San Francisco, San Mateo, Santa Clara, and Santa Cruz. It includes the following counties west of the California Aqueduct: Fresno, Kern, Kings, Merced, San Joaquin, and Stanislaus, as well as portions of the east-draining creeks from the Coast Range that flow under the California Aqueduct. Monterey County east of Highway 101 is also included in this clade as well as the northeastern portion of San Luis Obispo County bounded by Highways 101 and 46 (Figure 6). Like the California Aqueduct, the highways represent imperfect boundaries, but they are intended to approximate the Salinas Valley separating the Sierra de Salinas and Santa Lucia Range to the west (in the Southwest/South Coast clade) from the Gabilan and Diablo ranges in this clade.

Records of Foothill Yellow-legged Frogs occurring south of San Francisco Bay did not exist until specimens were collected in 1918 around what is now Pinnacles National Park in San Benito County, and little information exists on historical distribution and abundance within this clade (Storer 1923, Hayes et al. 2016). Figure 15 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, BIOS, and personal communications that are color coded by the most recent date of detection. Foothill Yellow-legged Frogs have been observed in at least 174 locations within this clade, 27 (15.5%) of which were in 2014 or later (CNDDB 2019).

The San Francisco Bay Area is heavily urbanized. Documented and possible extirpations are concentrated around the San Francisco Bay and sites at the southern portion of the clade's range (Figure 16); however, the latter may not have been resurveyed since their original observations in the 1940s through 1960s, with the exception of a 1994 survey conducted in Pinnacles National Park (Ibid.). Foothill Yellow-legged Frogs may be gone from Contra Costa County; eight of the nine CNDDB records from the county are museum specimens collected between 1891 and 1953. The most recent observation was two adults in a plunge pool in an intermittent tributary to Moraga Creek in 1997, but its veracity is dubious (CNDDB 2019, S. Kupferberg pers. comm. 2019). No recent (2010 or later) observations exist from San Mateo County (Ibid.). In addition, although not depicted, two populations south of Livermore (Alameda County) are also likely extirpated (M. Grefsrud pers. comm. 2019).

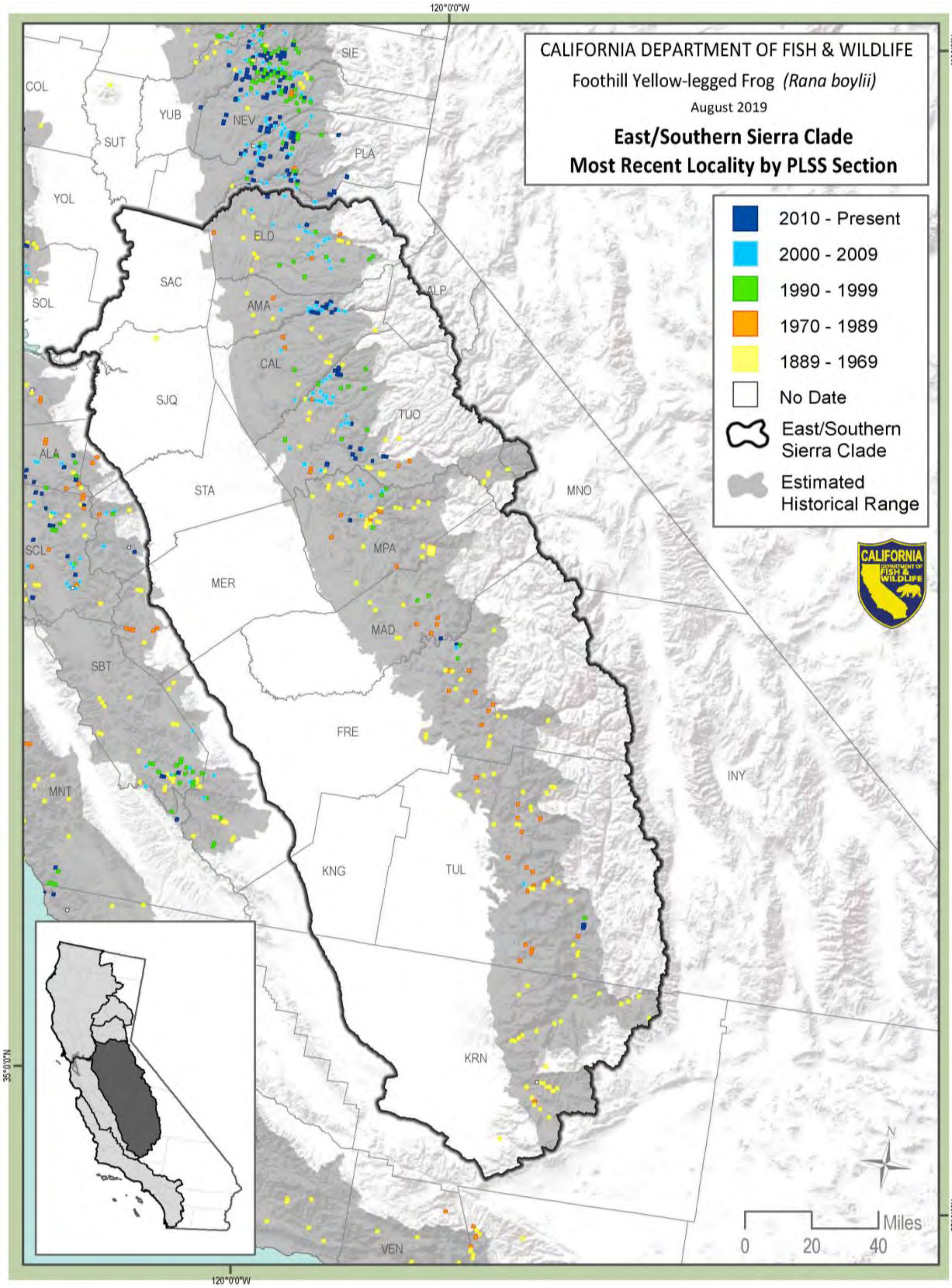


Figure 13. East/Southern Sierra clade observations from 1889-2019 by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CNDDB)

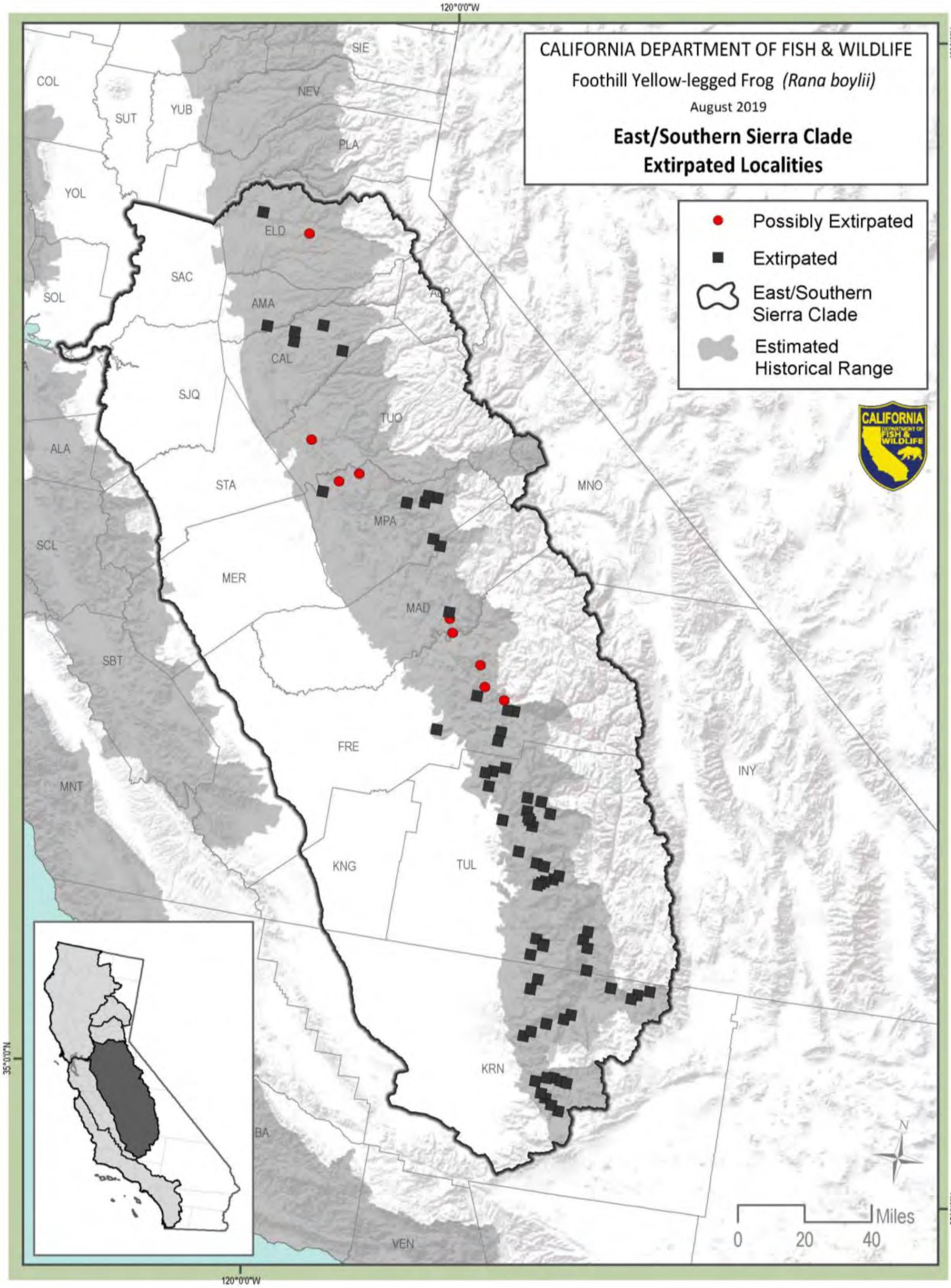


Figure 14. Possibly extirpated and extirpated East/Southern Sierra Foothill Yellow-legged Frog clade occurrences (CNDDB)

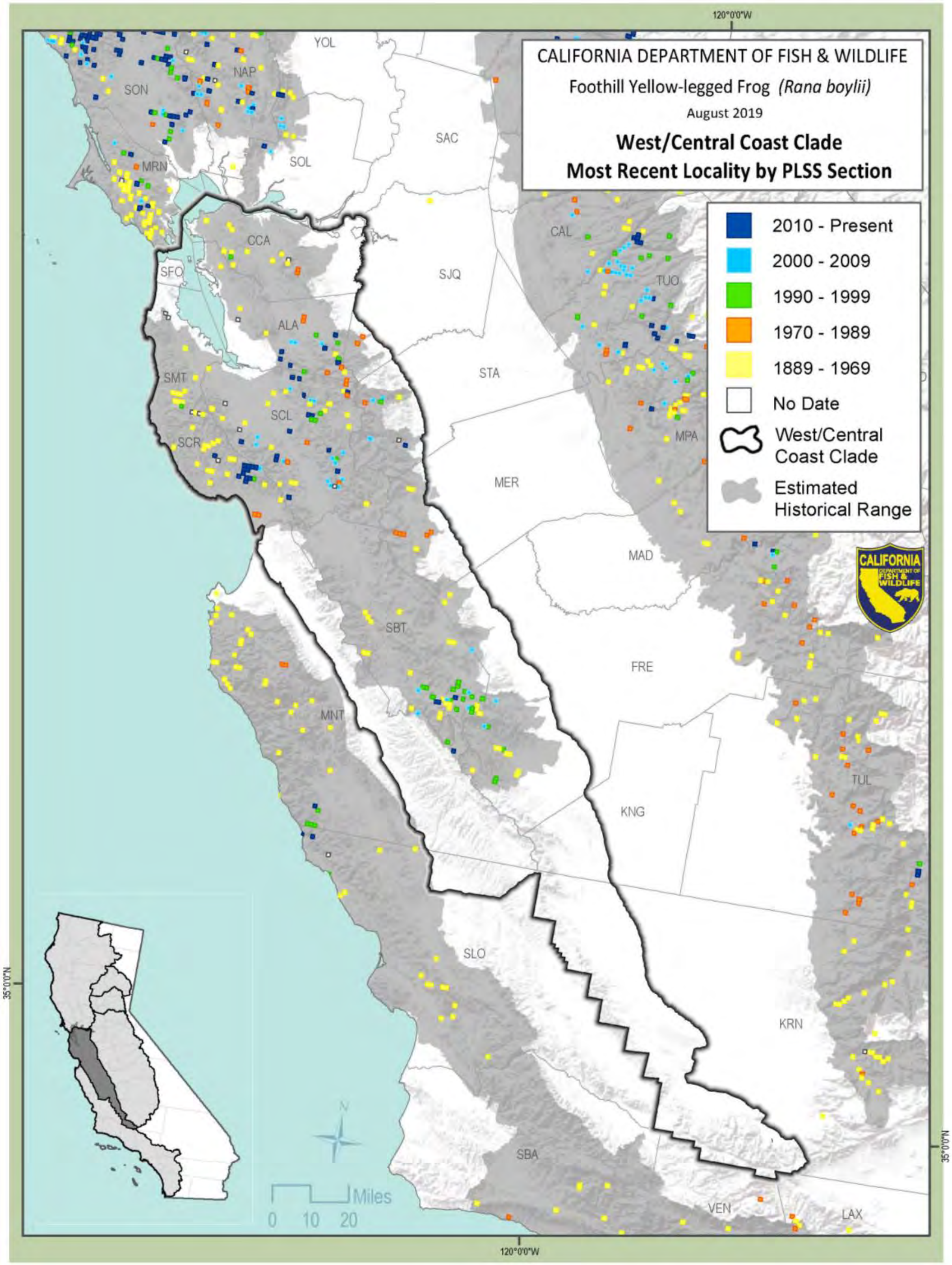


Figure 15. West/Central Coast clade observations from 1889-2019 by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CNDDB)

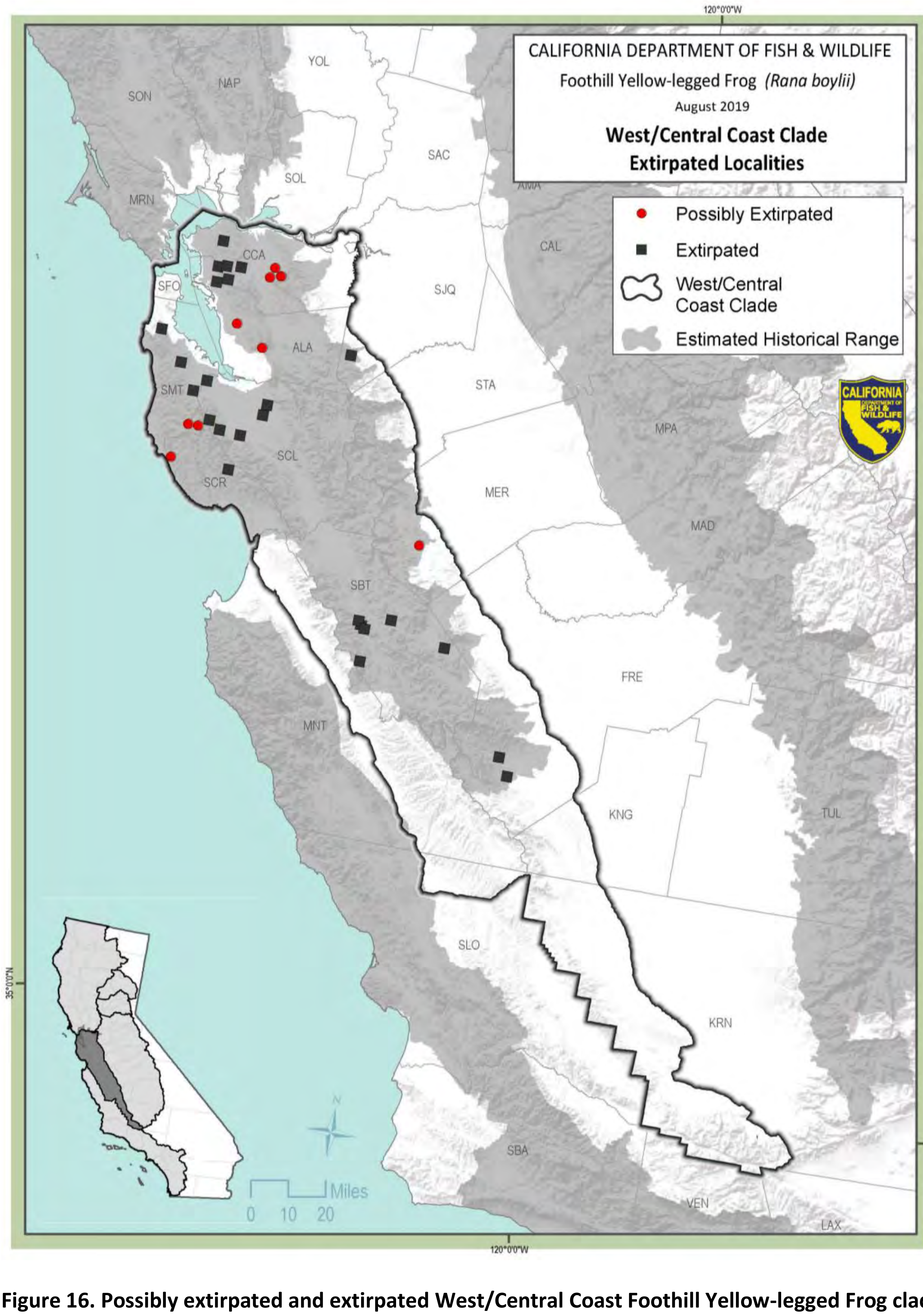


Figure 16. Possibly extirpated and extirpated West/Central Coast Foothill Yellow-legged Frog clade occurrences (CNDDB)

While historically-occupied lower elevation sites surrounding the San Francisco Bay and inland appear to be extirpated, there are (or were) some moderately abundant breeding populations remaining at higher elevations in Arroyo Hondo (Alameda County), Alameda Creek (Alameda and Santa Clara counties), Coyote and Upper Llagas creeks (Santa Clara County), and Soquel Creek (Santa Cruz County) with some scattered smaller populations also persisting in these counties (J. Smith pers. comm. 2016, 2017; CNDDB 2019). The Arroyo Hondo population is expected to lose approximately 1 mi of prime breeding habitat (i.e., supporting the highest density of egg masses on the creek) as the Calaveras Reservoir is refilled following its dam replacement project in 2019 (M. Grefsrud pers. comm. 2019). The Alameda Creek and Coyote Creek populations recently underwent large-scale mortality events, so their numbers may be lower than what is currently reported in the CNDDB (Adams et al. 2017a, Kupferberg and Catenazzi 2019). However, during 2019 surveys, Foothill Yellow-legged Frog egg mass density along Coyote Creek, including the location of the 2018 die-off, was comparable to those reported 15 years ago, although there may be a time lag before population-level effects are detected (S. Kupferberg pers. comm. 2019). Foothill Yellow-legged Frogs may be extirpated from Corral Hollow Creek in San Joaquin County, but a single individual was observed five years ago further up the drainage in Alameda County within an Off-Highway Vehicle park (CNDDB 2019). Few recent sightings of Foothill Yellow-legged Frogs in the east-flowing creeks are documented. They may still be extant in the headwaters of Del Puerto Creek (western Stanislaus County), but the records further downstream indicate bullfrogs (known predators and disease reservoirs) are moving up the system (Ibid.). Several locations in southern San Benito, western Fresno, and eastern Monterey counties have relatively recent (2000 and later) detections (Ibid.). However, while many of these sites supported somewhat large populations in the 1990s, the more recent records report fewer than ten individuals (Ibid.). The exception is a Monterey County site where 25 to 30 juveniles were observed in 2012 (Ibid.).

3.2.7 Southwest/South Coast Clade

Few early records exist for the Southwest/South Coast clade. Storer (1923) reported that Foothill Yellow-legged Frogs were collected for the first time in Monterey County in 1919 and that a specimen collected by Cope in 1889 in Santa Barbara and listed as *Rana temporaria pretiosa* may refer to the Foothill Yellow-legged Frog because as previously mentioned, the taxonomy of this species changed several times over the first century after it was named. Widespread extirpations occurred decades ago, detected primarily in the 1960s and 1970s, in southern California (Adams et al. 2017b). As a result, genetic samples were largely unavailable; nevertheless, the current known range of this clade is presumed to include the Coast Range west of the Salinas River from Monterey Bay in Monterey County south to the Transverse Range across to the San Gabriel Mountains in Los Angeles County. The Petition included references to museum specimens, collected below the putative elevation range of the Southern Mountain Yellow-legged Frog in Orange, San Bernardino, and San Diego counties, that should be examined to determine a conclusive identification. If the specimens from México were indeed Foothill Yellow-legged Frogs, additional historical populations in southern California cannot be completely ruled out. For management purposes and the Department’s listing recommendation, and based on the best available science, the boundaries of the Southwest/South Coast clade include the following whole counties: Orange, Santa Barbara, and Ventura. The eastern extent of this clade in Los

Angeles, Riverside, San Bernardino, and San Diego is bounded by the following subbasins: Los Angeles, San Diego, San Gabriel, San Jacinto, San Luis Rey-Escondido, Santa Ana, Santa Clara, and Santa Margarita. Monterey County west of Highway 101 and San Luis Obispo County south and west of Highways 101 and 46 are also part of this clade (Figure 6).

Figure 17 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, BIOS, and personal communications that are color coded by the most recent date of detection. Foothill Yellow-legged Frogs had been widespread and fairly abundant in this area until the late 1960s but were rapidly extirpated throughout the southern Coast Ranges and western Transverse Ranges by the mid-1970s (Sweet 1983, Adams et al. 2017b). Now the species has disappeared from nearly all know historically occupied locations (Figure 18), and only two populations from this clade are known to be extant, both located near the border of Monterey and San Luis Obispo counties (S. Sweet pers. comm. 2017, McCartney-Melstad et al. 2018, Peek 2018, CNDDB 2019). These populations appear to be extremely small and rapidly losing genetic diversity, making them at high risk of extirpation (McCartney-Melstad et al. 2018, Peek 2018).

4.0 FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

"The fortunes of the boylii *population fluctuate with those of the stream"* - Tracy I. Storer, 1925

Several past and ongoing activities have changed the watersheds upon which Foothill Yellow-legged Frogs depend, and many interact with each other exacerbating their adverse impacts. With such an expansive range in California, the degree and severity of these impacts on the species often vary by location. To the extent feasible, based on the best scientific information available, those differences are discussed below.

4.1 Dams, Diversions, and Water Operations

Foothill Yellow-legged Frogs evolved in a Mediterranean climate with predictably cool wet winters and hot dry summers; their life cycle is adapted to these conditions. In California and other areas with a Mediterranean climate, human demands for water are at the highest when runoff and precipitation are lowest, and annual water supply varies significantly but always follows the general pattern of peak discharge declining to base flow in the late spring or summer (Grantham et al. 2010). The Foothill Yellow-legged Frog's life cycle depends on this flow pattern and the specific habitat conditions it produces (see the Breeding and Rearing Habitat section). Dams are ubiquitous, but not evenly distributed, in California. Figure 19 depicts the locations of dams under the jurisdiction of the Army Corps of Engineers (ACOE) and the California Department of Water Resources (DWR). Figure 20 depicts the number of surface diversions per PLSS section within the Foothill Yellow-legged Frog's range (eWRIMS 2019).

Dam operations frequently change the amount, timing, and frequency of water availability; water temperature, depth, and velocity; the downstream capacity to transport sediment; and channel morphology, all of which can result in dramatic consequences for the Foothill Yellow-legged Frog's ability to survive and successfully reproduce. Several studies comparing Foothill Yellow-legged Frog

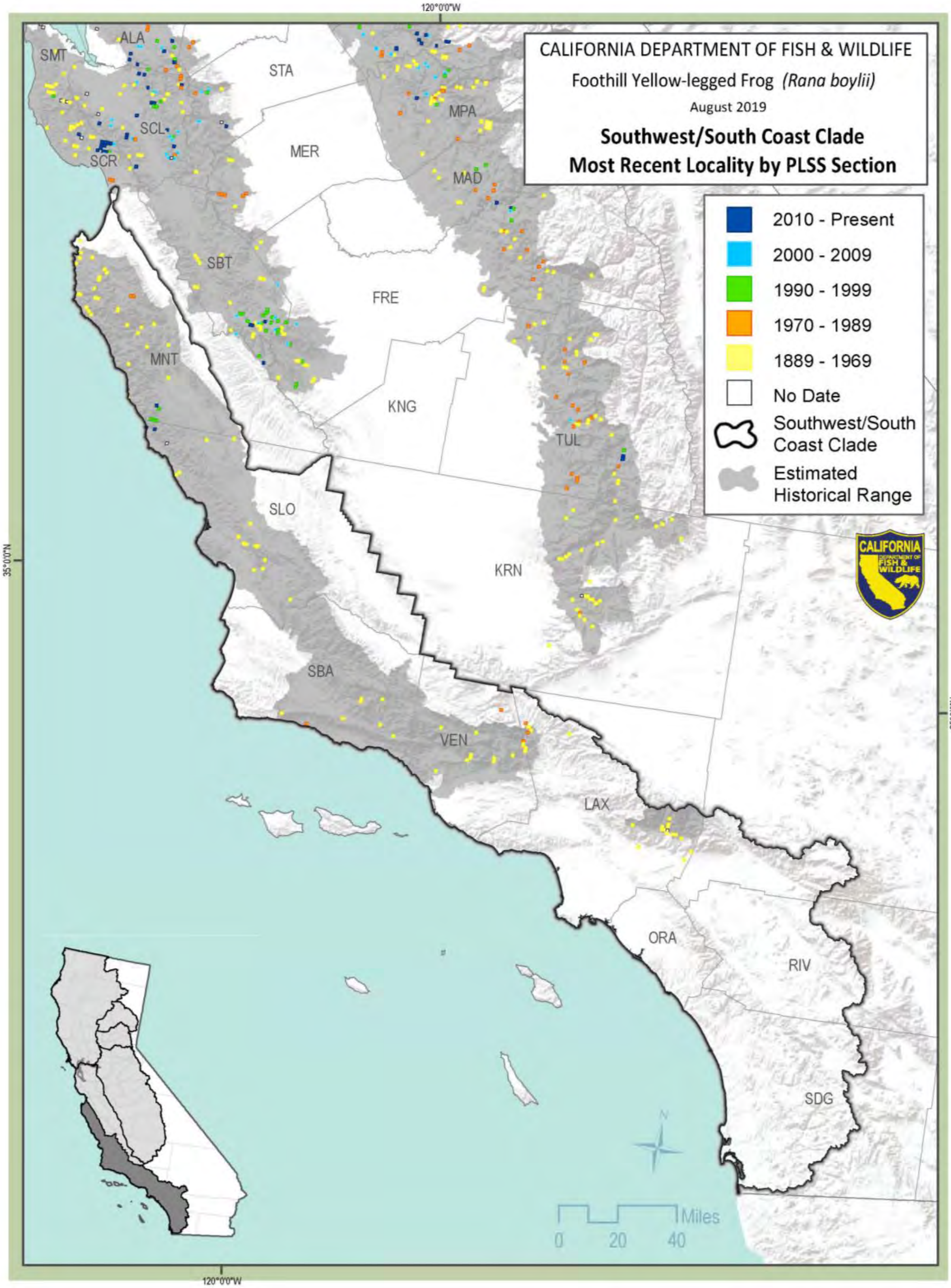


Figure 17. Southwest/South Coast clade observations from 1889-2019 by most recent sighting in a Public Land Survey System section (ARSSC, BIOS, CNDDB)

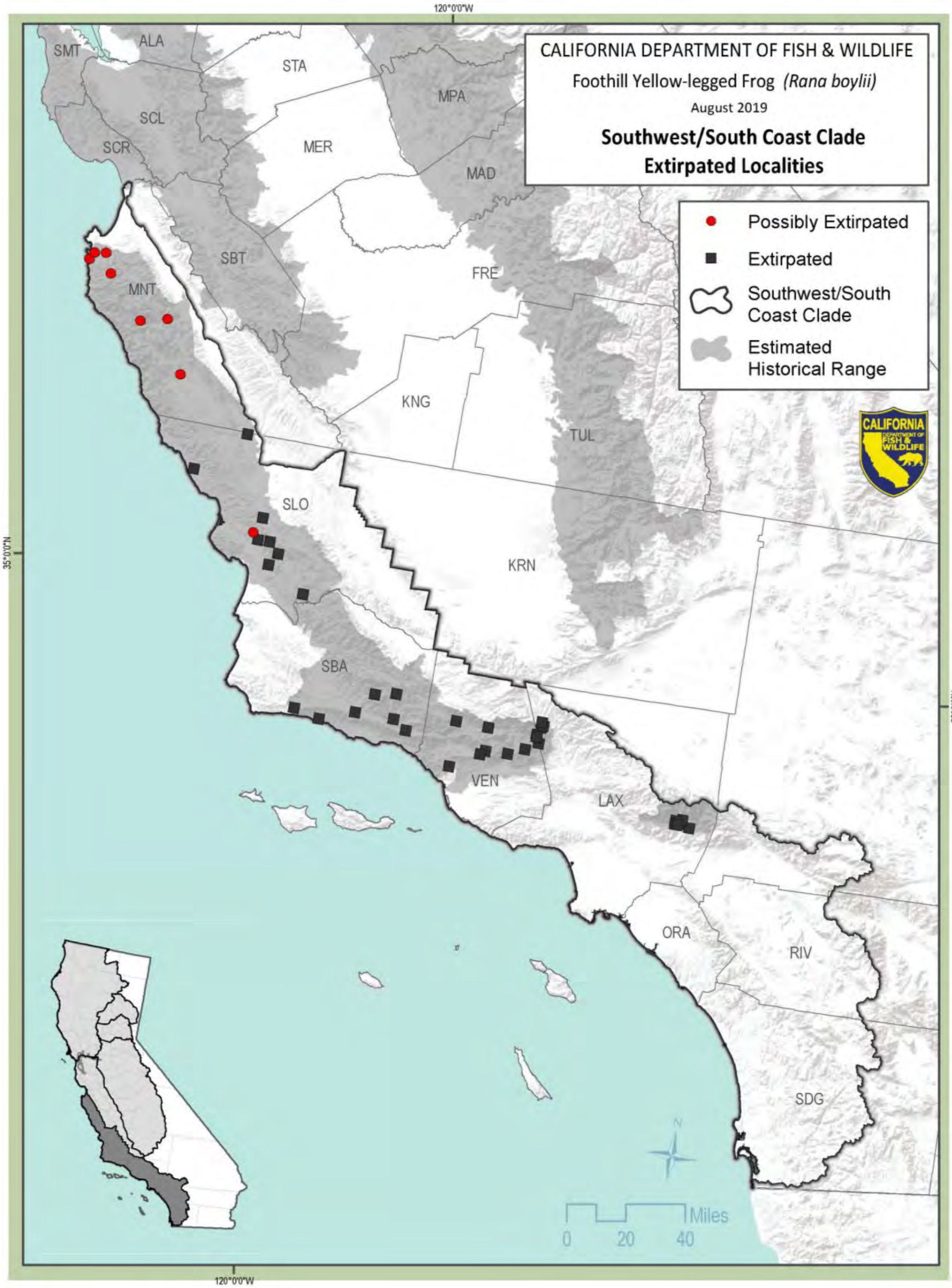


Figure 18. Possibly extirpated and extirpated Southwest/South Coast Foothill Yellow-legged Frog clade occurrences (CNDDB)

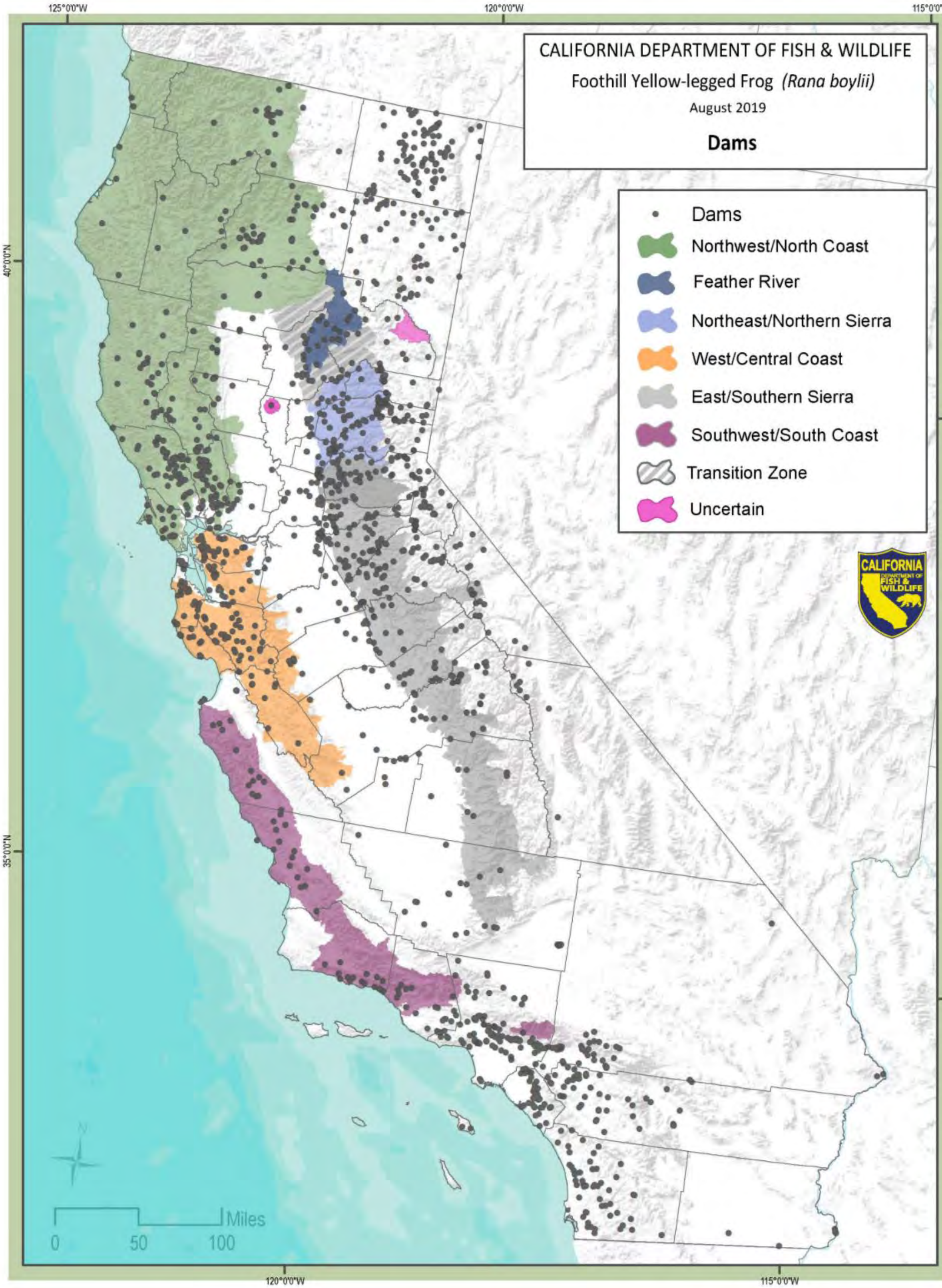


Figure 19. Locations of dams under the jurisdiction of the U.S. Army Corps of Engineers and the California Department of Water Resources in California (DWR, FRS)

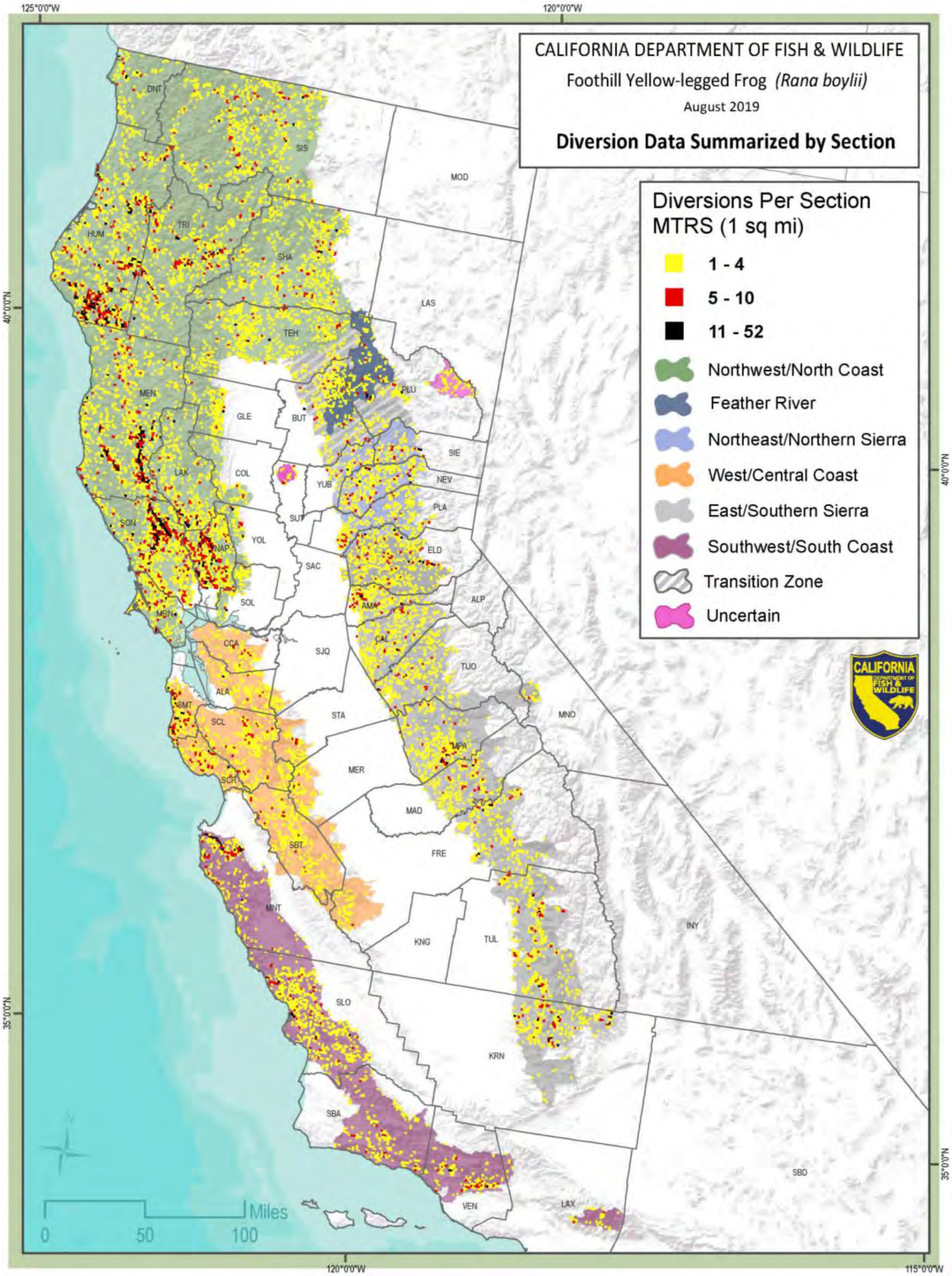


Figure 20. Number of surface water diversions per Public Land Survey System section within the Foothill Yellow-legged Frog's range in California (eWRIMs)

populations in regulated and unregulated reaches within the same watershed investigated potential dam-effects. These studies demonstrated that dams and their operations can result in several factors that contribute to population declines and possible extirpation. These factors include confusing breeding cues, scouring and stranding of egg masses and tadpoles, reducing the quality and quantity of breeding and rearing habitat, diminishing tadpole growth rate, creating barriers to gene flow, and supporting the establishment and spread of non-native species (Hayes et al. 2016). In addition, as previously discussed in the Population Structure and Genetic Diversity section, subpopulations of Foothill Yellow-legged Frogs on regulated rivers are more genetically isolated, and the type of water operations (hydropeaking vs. bypass flows) significantly affects the degree of connectivity and associated gene flow among them (Peek 2010, 2018; R. Peek pers. comm. 2019b). Both the Middle Fork of the American River and the Tuolumne River have hydropeaking reaches, and the Foothill Yellow-legged Frogs occupying them show marked genetic divergence and evidence of genetic bottlenecking (Peek 2018, R. Peek pers. comm. 2019b). Figure 21 depicts the locations of hydropower generating dams within and around the Foothill Yellow-legged Frog's range in California.

As discussed in the Seasonal Activity and Movements section, cues for Foothill Yellow-legged Frogs to start breeding include water temperature and velocity, two features altered by dams. Some dam operations result in reduced flows that are more stable over the course of a year than under unimpaired conditions, while others can result elevated and highly variable flows (R. Peek pers. comm. 2019a). In addition, dam operators are frequently required to maintain thermally appropriate water temperatures and flows for cold water adapted salmonids (USFWS and Hoopa Valley Tribe 1999, Wheeler et al. 2014). For example, late-spring and summer water temperatures on the mainstem Trinity River below Lewiston Dam have been reported to be up to 20°F cooler than average pre-dam temperatures, while average winter temperatures are slightly warmer (USFWS and Hoopa Valley Tribe 1999). As a result, Foothill Yellow-legged Frogs breed later in the season on the mainstem Trinity River compared to six nearby tributaries, and some mainstem reaches may never attain the minimum temperature required for successful breeding (Wheeler et al. 2014, Snover and Adams 2016). In addition, annual discharges past Lewiston Dam have been 10-30% of pre-dam flows and do not mimic the natural hydrograph (Lind et al. 1996). In other regulated rivers like the Middle Fork American, the water level can fluctuate nearly 3 ft in several hours, and higher than natural flows may be released for extended periods of time before returning to base flows (Peek 2010).

Aseasonal discharges from dams occur for several reasons including increased flow in late-spring and early summer to facilitate outmigration of salmonids, channel maintenance pulse flows, short-duration releases for recreational whitewater boating, rapid reductions after a spill (uncontrolled flows released down a spillway when reservoir capacity is exceeded) to retain water for power generation or water supply later in the year, peaking flows for hydropower generation, and sustained releases to maintain the seismic integrity of the dam (Lind et al. 1996, Jackman et al. 2004, Kupferberg et al. 2011b, Kupferberg et al. 2012, Snover and Adams 2016). The results of a Foothill Yellow-legged Frog population viability analysis (PVA) suggest that the likelihood a population will persist is very sensitive to early life stage mortality; the 30-year probability of extinction increases significantly with high levels of egg or tadpole scouring or stranding (Kupferberg et al. 2009c). For instance, in 1991 and 1992, all egg masses

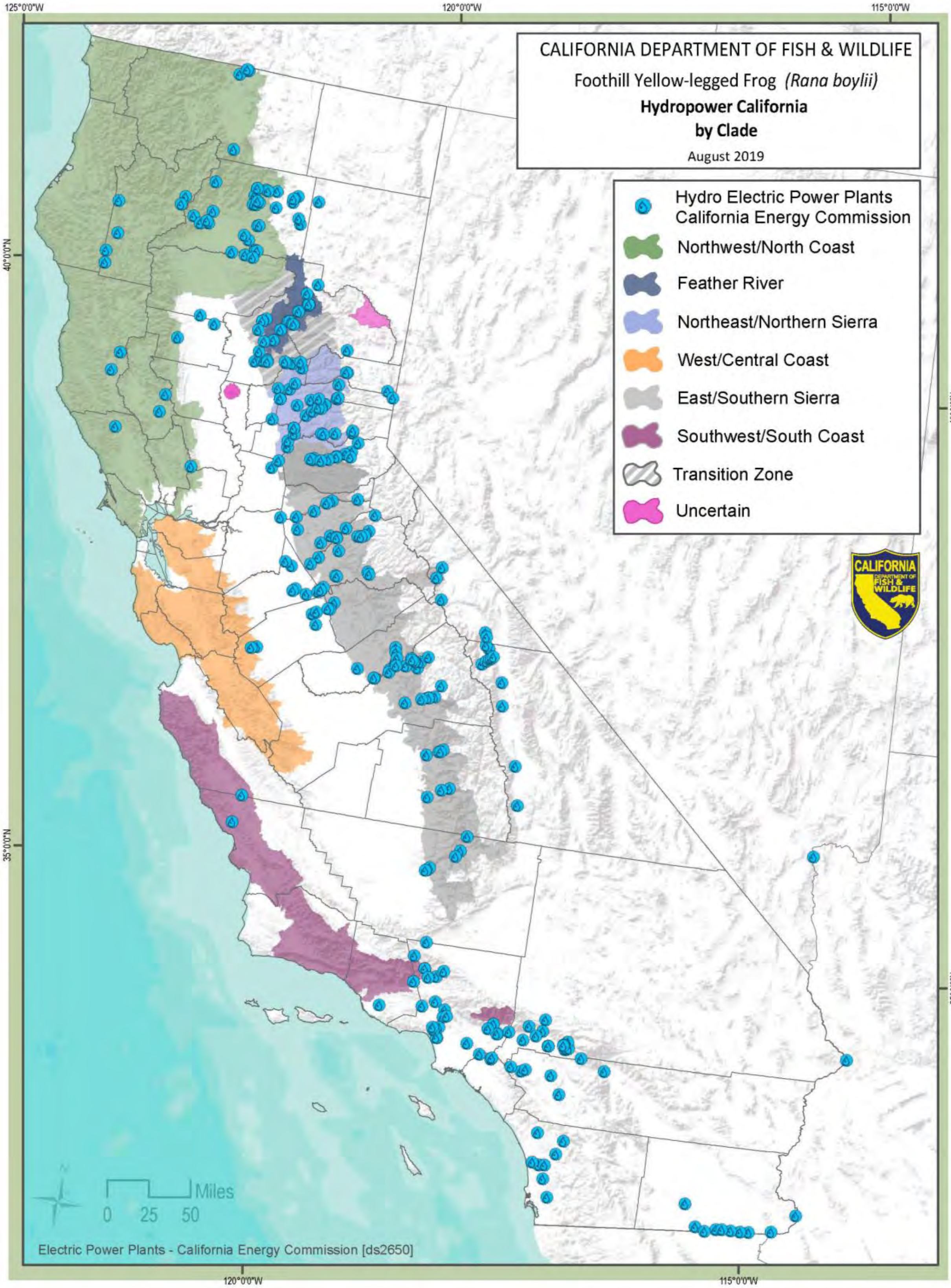


Figure 21. Locations of hydropower generating dams (BIOS)

laid before high flow releases to encourage outmigration of salmonids on the Trinity River were scoured away (Lind et al. 1996). According to the PVA, even a single annual pulse flow such as this, or for recreational boating, can result in a three- to five-fold increase in the 30-year extinction risk based on amount of tadpole mortality experienced (Kupferberg et al. 2009c). Management after natural spills can also lead to substantial mortality. For example, in 2006, Foothill Yellow-legged Frogs on the North Fork Feather River bred during a prolonged spill, and the rapid recession below Cresta Dam that followed stranded and desiccated all the eggs laid (Kupferberg et al. 2009b). Rapid flows can also increase predation risk if tadpoles are forced to seek shelter under rocks where crayfish and other invertebrate predators are more common or if they are displaced into the water column where their risk of predation by fish is greater (Ibid.).

The overall decrease in flows and frequency of large winter floods below dams can produce extensive changes to Foothill Yellow-legged Frog habitat quality. They reduce the formation of river bars that are regularly used as breeding habitat, and they create deeper and steeper channels with less complexity and fewer warm, calm, shallow edgewater habitats for tadpole rearing (Lind et al. 1996, Wheeler and Welsh 2008, Kupferberg et al. 2011b, Wheeler et al. 2014). For example, 26 years after construction of the Lewiston Dam on the Trinity River, habitat changes for 39 mi immediately downstream of the dam were evaluated (Lind et al. 1996). Riparian vegetation went from covering 30% of the riparian area pre-dam to 95% (Ibid.). Additionally, river bars made up 70% of the pre-dam riparian area compared to 4% post-dam, amounting to a 94% decrease in available Foothill Yellow-legged Frog breeding habitat (Ibid.).

Several features of riverine habitat below dams can decrease tadpole growth rate and other measures of fitness. As ectotherms, Foothill Yellow-legged Frogs require temperatures that support their metabolism, food conversion efficiency, growth, and development, and these temperatures may not be reached until late in the season, or not at all, when the water released is colder than their lower thermal limit (Kupferberg et al. 2011a, Catenazzi and Kupferberg 2013, Wheeler et al. 2014). Colder temperatures and higher flows reduce time spent feeding and food assimilation efficiency, resulting in slower growth and development (Kupferberg et al. 2011a,b; Catenazzi and Kupferberg 2018). Large bed-scouring winter floods promote greater *Cladophora glomerata* blooms, the filamentous green alga that dominates primary producer biomass during the tadpole rearing season (Power et al. 2008, Kupferberg et al. 2011a). The period of most rapid tadpole growth often coincides with blooms of highly nutritious and more easily assimilated epiphytic diatoms, so reduced flows can have food-web impacts on tadpole growth and survival (Power et al. 2008, Kupferberg et al. 2011a, Catenazzi and Kupferberg 2018). In addition, colder temperatures and fluctuating summer flows, such as those released for hydropower generation, can reduce the amount of algae available for grazing and can change the algal assemblage to one dominated by mucilaginous stalked diatoms like *Didymosphenia geminata* that have low nutritional value (Spring Rivers Ecological Sciences 2003, Kupferberg et al 2011a, Yarnell et al. 2013, Furey et al. 2014). Altered temperatures, flows, and food quality can contribute to slower growth and development, longer time to metamorphosis, smaller size at metamorphosis, and reduced body condition, which adversely impact fitness (Kupferberg et al. 2011b, Catenazzi and Kupferberg 2018).

As previously discussed, genetic divergence and diversity are strongly affected by river regulation (Peek 2010, 2018; Stillwater Sciences 2012). Foothill Yellow-legged Frogs primarily use watercourses as movement corridors, so the reservoirs created behind dams are often uninhabitable and represent barriers to gene flow (Bourque 2008; Peek 2010, 2018). This decreased connectivity can lead to loss of genetic diversity, which can reduce a species' ability to adapt to changing conditions (Palstra and Ruzzante 2008).

Decreased winter discharge below dams facilitates establishment and expansion of invasive bullfrogs, whose tadpoles require overwintering and are not well-adapted to flooding events (Lind et al. 1996, Doubledee et al. 2003). Where they occur, bullfrogs tend to dominate areas more altered by dam operations than less impaired areas, which support a higher proportion of native species (Moyle 1973, Fuller et al. 2011). In addition to downstream effects, the reservoirs created behind dams directly inundate and eliminate lotic (flowing) Foothill Yellow-legged Frog habitat, typically do not retain natural riparian communities due to fluctuating water levels, are often managed for human activities not compatible with the species' needs, and act as a source of introduced species upstream and downstream (Brode and Bury 1984, PG&E 2018). Moyle and Randall (1998) identified characteristics of sites with low native biodiversity in the Sierra Nevada foothills; they were often drainages that had been dammed and diverted in lower- to middle-elevations and dominated by introduced fishes and bullfrogs. Even small-scale operations can have significant effects. Some farming operations divert water during periods of high flows and store it in small impoundments for use during low flow-high demand times; these ponds can serve as sources for introduced species like bullfrogs to spread into areas where the habitat would otherwise be unsuitable (Kupferberg 1996b).

The mechanisms described above result in the widespread pattern of greater Foothill Yellow-legged Frog density in unregulated rivers and in reaches far enough downstream of a dam to experience minimal effects from it (Lind et al. 1996, Kupferberg 1996a, Bobzien and DiDonato 2007, Peek 2010). Foothill Yellow-legged Frog abundance in unregulated rivers averages five times greater than population abundance downstream of large dams (Kupferberg et al. 2012). Figure 22 depicts a comprehensive collection of egg mass density data, where at least four years of surveys have been undertaken, showing much lower abundance in regulated rivers (Peek and Kupferberg 2016). In California, Foothill Yellow-legged Frog presence is associated with an absence of dams or with only small dams far upstream (Lind 2005, Kupferberg et al. 2012). Hydropower generation from Sierra Nevada rivers accounts for nearly half its statewide production and about 9% of all electrical power used in California (Dettinger et al. 2018). Every major stream below approximately 2,000 ft in the Sierra Nevada has at least one large reservoir (≥100,000 ac-ft), and many have multiple medium and small ones (Hayes et al. 2016). Because of this, Catenazzi and Kupferberg (2017) posit that the dam-effect on Foothill Yellow-legged Frog populations is likely greater in the Sierra Nevada than the Coast Range because in the former dams are more often constructed in a series along a river and spaced close enough together that suitable breeding temperatures may never be attained in the intervening reaches.

4.2 Pathogens and Parasites

Perhaps the most widely recognized amphibian disease is chytridiomycosis, which is caused by the fungal pathogen *Batrachochytrium dendrobatidis* (Bd). Implicated in the decline of over 500 amphibian species, including 90 presumed extinctions, it represents the greatest recorded loss of biodiversity

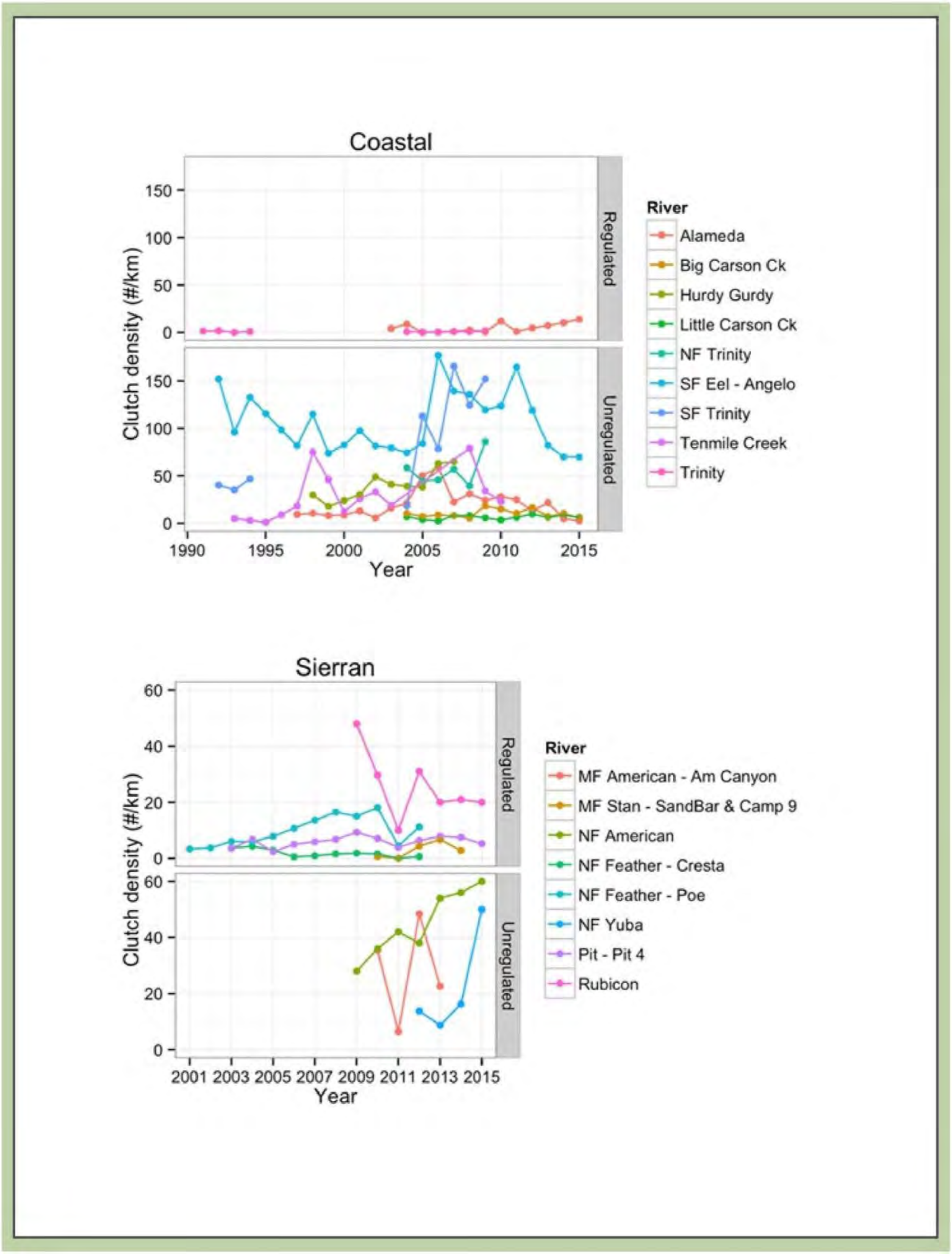


Figure 22. Foothill Yellow-legged Frog Egg mass density estimates along the coast from 1990-2015 and the Sierra Nevada from 2001-2015 (Peek and Kupferberg 2016)

attributable to a disease (Scheele et al. 2019). The global trade in American Bullfrogs (primarily for food) is connected to the disease's spread because the species can persist with low-level Bd infections without developing chytridiomycosis (Yap et al. 2018). Previous studies suggested Foothill Yellow-legged Frogs may not be susceptible to Bd-associated mass mortality; skin peptides strongly inhibited growth of the fungus in the lab, and the only detectable difference between Bd+ and Bd- juvenile Foothill Yellow-legged Frogs was slower growth (Davidson et al. 2007). At Pinnacles National Park in 2006, 18% of post-metamorphic Foothill Yellow-legged Frogs tested positive for Bd; all were asymptomatic and at least one Bd+ Foothill Yellow-legged Frog subsequently tested negative, demonstrating an ability to shed the fungus (Lowe 2009). However, recent studies have found historical evidence of Bd contributing to the extirpation of Foothill Yellow-legged Frogs in southern California, an acute die-off in 2013 in the Alameda Creek watershed, and another in 2018 in Coyote Creek (Adams et al. 2017a,b; Kupferberg and Catenazzi 2019). Evaluation of museum specimens indicated a lower Bd prevalence (proportion of individuals infected) in Foothill Yellow-legged Frogs than most other co-occurring amphibians in southern California in the first part of the 20th century, but it spiked in the 1970s just prior to the last observation of an individual in 1977 (Adams et al. 2017b). Two museum specimens collected in 1966, one from Santa Cruz County and the other from Alameda County, provide the earliest evidence of Bd in Foothill Yellow-legged Frogs in central California (Padgett-Flohr and Hopkins 2009). In contrast to the southern California results, Foothill Yellow-legged Frogs possessed the highest Bd prevalence among all amphibians tested in coastal Humboldt County in 2013 and 2014; however, zoospore (the aquatic dispersal agent) loads were well below the presumed lethal density threshold (Ecoclub Amphibian Group et al. 2016).

In addition to bullfrogs, the native Pacific Treefrog (*Pseudacris regilla*) seems immune to the lethal effects of chytridiomycosis, and owing to its broad ecological tolerances, more terrestrial lifestyle, and relatively large home range size and dispersal ability, the species is ubiquitous across California (Padgett-Flohr and Hopkins 2009). In a laboratory experiment, Bd-infected Pacific Treefrogs shed an average of 68 zoospores/min, making them the prime candidate for spreading and maintaining Bd in areas where bullfrogs do not occur (Padgett-Flohr and Hopkins 2009, Reeder et al. 2012). In the wild in Sixty Lakes Basin (Fresno County), Pacific Treefrog populations persisted at 100% of sites where the Southern Mountain Yellow-legged Frog had been extirpated from 72% of its formerly occupied sites due to a Bd outbreak (Reeder et al. 2012). This is consistent with the results of a model that incorporated Bd habitat suitability, host availability, and invasion history in North America, which concluded west coast mountain ranges were at the greatest risk from the disease (Yap et al. 2018).

Several other pathogens and parasites have been associated with Foothill Yellow-legged Frogs, but none have been ascribed to large-scale mortality events. Another fungus, a water mold (*Saprolegnia* sp.) carried by fish, is an important factor in amphibian embryo mortality in the Pacific Northwest (Blaustein et al. 1994, Kiesecker and Blaustein 1997). Fungal infections of Foothill Yellow-legged Frog egg masses, potentially from *Saprolegnia*, have been observed in the mainstem Trinity River (Ashton et al. 1997). *Saprolegnia* infection is more likely to occur in ponds and lakes, particularly if stocked by hatchery-raised fish into previously fishless areas and when frogs use communal oviposition sites, so it likely does not represent a major source of mortality in Foothill Yellow-legged Frogs (Blaustein et al. 1994, Kiesecker and Blaustein 1997). However, they may be more susceptible to *Saprolegnia* infection when exposed to other environmental stressors that compromise their immune defenses (Blaustein et al. 1994, Kiesecker and Blaustein 1997).

The trematode parasite *Ribeiroia ondatrae* is responsible for limb malformations in ranids (Stopper et al. 2002). *Ribeiroia ondatrae* was detected on a single Foothill Yellow-legged Frog during a study on malformations, but its morphology was normal (Kupferberg et al. 2009a). The results of the study instead linked malformations in Foothill Yellow-legged Frog tadpoles and young-of-year to the Anchor Worm (*Lernaea cyprinacea*), a parasitic copepod from Eurasia (Ibid.). Prevalence of malformations was low, under 4% of the population in both years of study, but there was a pattern of infected individuals metamorphosing at a smaller size, which as previously mentioned can have implications on fitness (Ibid.). Three other species of helminths (parasitic worms) were encountered during the study (*Echinostoma* sp., *Manodistomum* sp., and *Gyrodactylus* sp.); their relative impact on their hosts is unknown, but at least one Foothill Yellow-legged Frog had 700 echinostome cysts in its kidney (Ibid.). Bursey et al. (2010) discovered 13 species of helminths in and on Foothill Yellow-legged Frogs from Humboldt County. Most are common in anurans, and some are generalists with multiple possible hosts, but studies on their impact on Foothill Yellow-legged Frogs are lacking (Ibid.).

4.3 Introduced Species

Species not native to an area, but introduced, can alter food webs and ecosystem processes through predation, competition, hybridization, disease transmission, and habitat modification. Native species lack evolutionary history with introduced species, and early life stages of native anurans are particularly susceptible to predation by aquatic non-native species (Kats and Ferrer 2003). Because introduced species often establish in highly modified habitats, it can be difficult to differentiate between impacts from habitat degradation and the introduced species (Fisher and Shaffer 1996). However, native amphibians have been frequently found successfully reproducing in heavily altered habitats when introduced species were absent, suggesting introduced species themselves can impose an appreciable adverse effect (Ibid.). Numerous introduced species have been documented to adversely impact Foothill Yellow-legged Frogs or are suspected of doing so.

American Bullfrogs were introduced to California from the eastern U.S. around the turn of the 20th century, likely in response to overharvest of native ranids by the frog-leg industry that accompanied the Gold Rush (Jennings and Hayes 1985). Nearly 50 years ago, Moyle (1973) reported that distributions of Foothill Yellow-legged Frogs and bullfrogs in the Sierra Nevada foothills were nearly mutually exclusive. He speculated that bullfrog predation and competition may be causal factors in their disparate distributions in addition to the habitat degradation from dams and diversions that facilitated the bullfrog invasion in the first place. In a study along the South Fork Eel River and one of its tributaries, Foothill Yellow-legged Frog abundance was nearly an order of magnitude (10 times) lower in reaches where bullfrogs were well established (Kupferberg 1997a). At a site in Napa Valley, after bullfrogs were eradicated, Foothill Yellow-legged Frogs, among other native species, recolonized the area (Wilcox and Alvarez 2019). In a mesocosm experiment, Foothill Yellow-legged Frog tadpole survival in the presence of bullfrog tadpoles was half that of control enclosures containing only Foothill Yellow-legged Frogs, and they weighed approximately one-quarter less at metamorphosis (Kupferberg 1997a). The mechanism for these declines appeared to be the reduction of high-quality algae by bullfrog tadpole grazing, as opposed to any behavioral or chemical interference (Ibid.). Adult bullfrogs, which can get very large (3.5-6.0 inches), also directly consume Foothill Yellow-legged Frogs, including adults (Moyle 1973, Crayon 1998, Powell et al. 2016).

As discussed briefly in the Pathogens and Parasites section, American Bullfrogs act as reservoirs and vectors of the lethal chytrid fungus. In museum specimens from both southern and central California, Bd was detected in bullfrogs before it was detected in Foothill Yellow-legged Frogs in the same area (Padgett-Flohr and Hopkins 2009, Adams et al. 2017b). During a die-off from chytridiomycosis that commenced in 2013, Bd prevalence and load in Foothill Yellow-legged Frogs was positively predicted by bullfrog presence (Adams et al. 2017a). A similar die-off in 2018 from a nearby county appears to be related to transmission by bullfrogs as well (Kupferberg and Catenazzi 2019). In addition, male Foothill Yellow-legged Frogs have been observed amplexing female bullfrogs, which may not only constitute wasted reproductive effort but could serve to increase their likelihood of contracting Bd (Lind et al. 2003a). In fact, adult males were more likely to be infected with Bd than females or juveniles during the recent die-off in Alameda Creek (Adams et al. 2017a). African Clawed Frogs (*Xenopus laevis*) have also been implicated in the spread of Bd in California because, like bullfrogs, they are asymptomatic carriers (Padgett-Flohr and Hopkins 2009). However, African Clawed-Frog distribution only minimally overlaps with the Foothill Yellow-legged Frog's range unlike the widespread bullfrog (Stebbins and McGuinness 2012).

Hayes and Jennings (1986) observed a negative association between the abundance of introduced fish and Foothill Yellow-legged Frogs. Rainbow trout (*Onchorynchus mykiss*) and green sunfish (*Lepomis cyanellus*) are suspected of destroying egg masses (Van Wagner 1996). Bluegill sunfishes (*L. macrochirus*) are likely predators; in captivity when offered eggs and tadpoles of two ranid species, they consumed both life stages but a significantly greater number of tadpoles (Werschkul and Christensen 1977). Common hatchery-stocked fish like brook (*Salvelinus fontinalis*) and rainbow trout commonly carry *Saprolegnia* (Blaustein et al. 1994). In addition, presence of non-native fish can facilitate bullfrog invasions by reducing the density of macroinvertebrates that prey on their tadpoles (Adams et al. 2003). Foothill Yellow-legged Frog tadpoles raised from eggs from sites with and without smallmouth bass (*Micropterus dolomieu*) did not differ in their responses to exposure to the non-native, predatory bass and a native, non-predatory fish (Paoletti et al. 2011). This result suggests that Foothill Yellow-legged Frogs have not yet evolved a recognition of bass as a threat, which makes them more vulnerable to predation (Ibid.).

Introduced into several areas within the Coast Range and Sierra Nevada, signal crayfish have been recorded preying on Foothill Yellow-legged Frog egg masses and are suspected of preying on their tadpoles based on observations of tail injuries that looked like scissor snips (Riegel 1959, Wiseman et al. 2005). The introduced red swamp crayfish (*Procambarus clarkii*) likely also preys on Foothill Yellow-legged Frogs. Because Foothill Yellow-legged Frogs evolved with the native Shasta Crayfish (*Pacifastacus fortis*) in some parts of northern California, frogs from those areas may more effectively avoid crayfish predation than in other parts of the state where they are not native (Riegel 1959, USFWS 1998, Kats and

Ferrer 2003). The Foothill Yellow-legged Frog's naiveté to crayfish was demonstrated in a study that showed they did not change behavior when exposed to signal crayfish chemical cues; however, once the crayfish was released and consuming Foothill Yellow-legged Frog tadpoles, the survivors, likely reacting to chemical cues from dead tadpoles, exhibited a predator-avoidance behavior (Kerby and Sih 2015).

4.4 Sedimentation

Several anthropogenic activities, some of which are described in greater detail below, can artificially increase sedimentation into waterways occupied by Foothill Yellow-legged Frogs and adversely impact biodiversity (Moyle and Randall 1998). These activities include but are not limited to mining, agriculture, overgrazing, timber harvest, and poorly constructed roads (Ibid.). Increased fine sediments can substantially degrade Foothill Yellow-legged Frog habitat quality. Heightened turbidity decreases light penetration that phytoplankton and other aquatic plants require for photosynthesis (Cordone and Kelley 1961). When silt particles fall out of the water column, they can destroy algae by covering the bottom of the stream (Ibid.). Algae are not only important for Foothill Yellow-legged Frog tadpoles as forage but also for oxygen production (Ibid.). Sedimentation may impede attachment of egg masses to substrate (Ashton et al. 1997). The effect of silt accumulation on embryonic development is unknown, but it does make them less visible, which could decrease predation risk (Fellers 2005). Fine sediments can fill interstitial spaces between rocks that tadpoles use for shelter from high velocity flows and cover from predators and that serve as sources for aquatic invertebrate prey for post-metamorphic Foothill Yellow-legged Frogs (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b).

4.5 Mining

Current mining practices, as well as legacy effects from historical mining operations, may adversely impact Foothill Yellow-legged Frogs through contaminants, direct mortality, habitat destruction and degradation, and behavioral disruption. While mercury in streams can result from atmospheric deposition, storm-induced runoff of naturally occurring mercury, agricultural runoff, and geothermal springs, runoff from historical mine sites mobilizes a significant amount of mercury (Foe and Croyle 1998, Alpers et al. 2005, Hothem et al. 2010). Beginning in the mid-1800s, extensive mining occurred in the Coast Range to supply mercury for gold mining in the Sierra Nevada, causing widespread contamination of both mountain ranges and the rivers in the Central Valley (Foe and Croyle 1998). Studies on Foothill Yellow-legged Frog tissues collected from the Cache Creek (Coast Ranges) and Greenhorn Creek (Sierra Nevada) watersheds revealed mercury bioaccumulation concentrations as high as 1.7 and 0.3 ppm, respectively (Alpers et al. 2005, Hothem et al. 2010). For context, the U.S. Environmental Protection Agency's mercury criterion for issuance of health advisories for fish consumption is 0.3 ppm; concentrations exceeded this threshold in Foothill Yellow-legged Frog tissues at 62% of sampling sites in the Cache Creek watershed (Hothem et al. 2010). Bioaccumulation of this powerful neurotoxin can cause deleterious impacts on amphibians including inhibited growth, decreased survival to metamorphosis, increased malformations, impaired reproduction, and other sublethal effects (Zillioux et al. 1993, Unrine et al. 2004). In a study measuring Sierra Nevada watershed health, Moyle and Randall (1998) reportedly found very low biodiversity in streams that were heavily polluted by acidic water leaching from historical mines. Acidic drainage measured as low as pH 3.4 from some mined areas in the northern Sierra Nevada (Alpers et al. 2005).

Widespread suction dredging for gold occurred in the Foothill Yellow-legged Frog's California range until enactment of a moratorium on issuing permits in 2009 (Hayes et al. 2016). Suction dredging vacuums up the contents of the streambed, passes them through a sluice box to separate the gold, and then deposits the tailings on the other side of the box (Harvey and Lisle 1998). While most habitat disturbance is localized and minor, it can be especially detrimental if it degrades or destroys breeding and rearing habitat through direct disturbance or sedimentation (Ibid.). In addition, this activity can lead to direct mortality of early life stages through entrainment, and those eggs and tadpoles that do survive passing through the suction dredge may experience greater mortality due to subsequent unfavorable physiochemical conditions and possible increased predation risk (Ibid.). Suction dredging can also reduce the availability of invertebrate prey, although this impact is typically short-lived (Ibid.). Suction dredging alters stream morphology, and relict tailing ponds can serve as breeding habitat for bullfrogs in areas that would not normally support them (Fuller et al. 2011). However, in some areas these mining holes have reportedly benefited Foothill Yellow-legged Frogs by creating cool persistent pools through the summer at one Sierra Nevada site that adult females appeared to prefer (Van Wagner 1996). Senate Bill 637 (2015) directs the Department to work with the State Water Resources Control Board (SWRCB) to develop a statewide water quality permit that would authorize the use of vacuum or suction dredge equipment in California under conditions set forth by the two agencies. SWRCB staff, in coordination with Department staff, are in the process of collecting additional information to inform the next steps that will be taken by the SWRCB (SWRCB 2019).

Instream aggregate (gravel) mining continues today and can have similar impacts to suction dredge mining by removing, processing, and relocating stream substrates (Olson and Davis 2009). This type of mining typically removes bars used as Foothill Yellow-legged Frog breeding habitat and reduces habitat heterogeneity by creating flat wide channels (Kupferberg 1996a, Yarnell 2005). When listed salmonids are present, typically mining must be conducted above the wetted edge, but this practice can create perennial off-channel bullfrog breeding ponds (M. van Hattem pers. comm. 2018).

4.6 Agriculture

California is the nation's largest agricultural producer and exporter (CDFA 2018a). Direct loss of Foothill Yellow-legged Frog habitat from wildland conversion to agriculture is likely rare overall because the typically rocky riparian areas they inhabit are usually not conducive to farming, but removal of riparian vegetation directly adjacent to streams for agriculture is more common and widespread. The U.S. Department of Agriculture classifies 9.6 million ac in California as cropland, which amounts to less than 10% of the state's land area, and 70% of this occurs in the Central Valley between Redding and Bakersfield (Martin et al. 2018). In addition, several indirect impacts can adversely affect Foothill Yellow-legged Frogs at substantial distances from agricultural operations such as effects from runoff (sediments and agrochemicals), drift and deposition of airborne pollutants, water diversions, and creation of novel habitats like impoundments that facilitate spread of detrimental non-native species. As sedimentation and introduced species impacts were previously discussed, this section instead focuses on the other possible adverse impacts.

4.6.1 Agrochemicals

Many species of amphibians, particularly ranids, have experienced declines throughout California, but the most dramatic declines have occurred in the Sierra Nevada east of the San Joaquin Valley where 60% of the total pesticide usage in the state was sprayed (Sparling et al. 2001). Agrochemicals applied to crops in the Central Valley can volatilize, travel through the atmosphere, and deposit in higher elevations (LeNoir et al. 1999). Pesticide concentrations diminish as elevations increase in the lower foothills but change little from 1,750 to 6,300 ft, which coincides with the Foothill Yellow-legged Frog's elevational range (Ibid). Foothill Yellow-legged Frog absence at historically occupied sites in California significantly correlated with agricultural land use within 3.1 mi (Davidson et al. 2002). Figure 23 depicts the positive relationship between Foothill Yellow-legged Frog declines and the amount of upwind agriculture, suggesting airborne agrochemicals may be a contributing factor (Ibid.). Cholinesterase-inhibitors (most organophosphates and carbamates), which disrupt nerve impulse transmission, were more strongly associated with population declines than other pesticide types (Davidson 2004). Olson and Davis (2009) and Lind (2005) also reported a negative correlation between Foothill Yellow-legged Frog presence and proximity and quantity of nearby agriculture in Oregon and across the species' entire range, respectively.

Lethal and sublethal effects of agrochemicals on amphibians can take two general forms: direct toxicity and food-web effects. Sublethal doses of agrochemicals can interact with other environmental stressors to reduce fitness. Foothill Yellow-legged Frog tadpoles showed significantly greater vulnerability to the lethal and sublethal effects of carbaryl than Pacific Treefrogs (Kerby and Sih 2015). An inverse relationship exists between carbaryl concentration and Foothill Yellow-legged Frog activity, and their 72-hr LC_{50} (concentration at which 50% die) measured one-fifth that of Pacific Treefrogs (Ibid.). Carbaryl slightly decreased Foothill Yellow-legged Frog development rate, but it significantly increased susceptibility to predation by signal crayfish despite nearly no mortality in the pesticide- and predator-only treatments (Ibid.). Sparling and Fellers (2009) also found Foothill Yellow-legged Frogs were significantly more sensitive to pesticides (chlorpyrifos and endosulfan in this study) than Pacific Treefrogs; their 96-hr LC_{50} was nearly five-times less than for treefrogs. Endosulfan was nearly 121 times more toxic to Foothill Yellow-legged Frogs than chlorpyrifos, and water samples from the Sierra Nevada have contained endosulfan concentrations greater than the LC_{50} for the species in some parts of the species' range (Ibid.). Sublethal effects included smaller body size, slower development rate, and increased time to metamorphosis (Ibid.). Sparling and Fellers (2007) determined the organophospates chlorpyrifos, malathion, and diazinon can harm Foothill Yellow-legged Frog populations, and their oxon derivatives (the resultant compounds once they begin breaking down in the body) were 10 to 100 times more toxic than their respective parental forms.

Extrapolating the results of studies on other ranids to Foothill Yellow-legged Frogs should be undertaken with caution; however, those studies can demonstrate additional potential adverse impacts of exposure to agrochemicals. Relyea (2005) discovered that Roundup®, a common herbicide, could cause rapid and

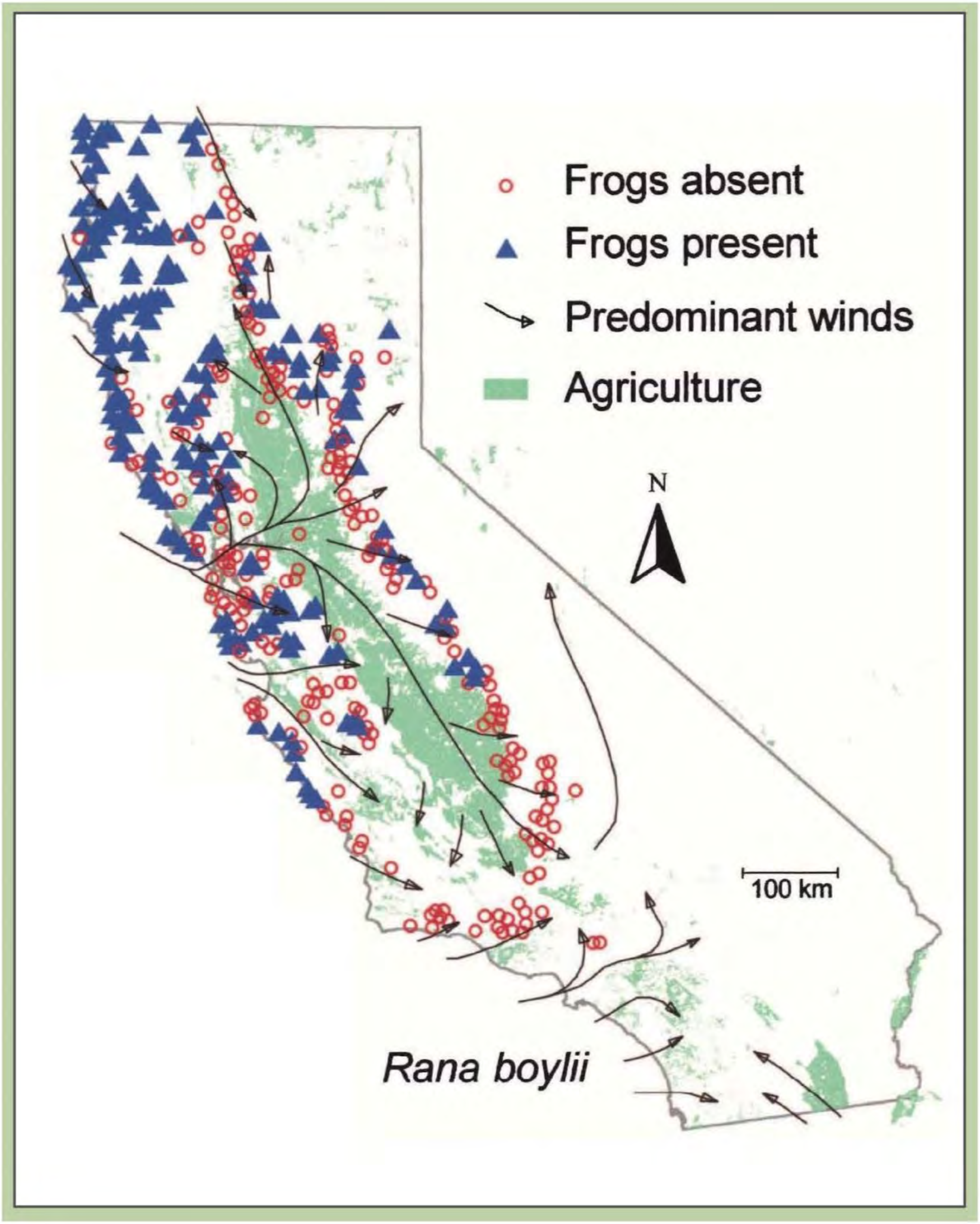


Figure 23. Relationship of Foothill Yellow-legged Frog occupancy to agriculture and prevailing winds from Davidson et al. (2002)

widespread mortality in amphibian tadpoles through direct toxicity, and overspray at the manufacturer's recommended application concentrations would be highly lethal. Atrazine, another common herbicide, has been implicated in disrupting reproductive processes in male Northern Leopard Frogs (Rana pipiens) by slowing gonadal development, inducing hermaphroditism, and even producing oocytes (eggs) (Hayes et al. 2003). However, recent research on sex reversal in wild populations of Green Frogs (R. clamitans) suggests the phenomenon may be a relatively common natural process unrelated to environmental contaminants, requiring more research (Lambert et al. 2019). Malathion, a common organophosphate insecticide, that rapidly breaks down in the environment, applied at low concentrations caused a trophic cascade that resulted in reduced growth and survival of two species of ranid tadpoles (Relyea and Diecks 2008). Malathion caused a reduction in the amount of zooplankton, which resulted in a bloom of phytoplankton and an eventual decline in periphyton, an important food source for tadpoles (Ibid.). In contrast, Relyea (2005) found that some insecticides increased amphibian tadpole survival by reducing their invertebrate predators. Runoff from agricultural areas can contain fertilizers that input nutrients into streams and increase productivity, but they can also result in harmful algal blooms (Cordone and Kelley 1961). In addition, exposure to pesticides can result in immunosuppression and reduce resistance to the parasites that cause limb malformations (Kiesecker 2002, Hayes et al. 2006).

4.6.2 Cannabis

An estimated 60-70% of the cannabis (*Cannabis indica* and *C. sativa*) used in the U.S. from legal and illegal sources is grown in California, and most comes from the Emerald Triangle, an area comprised of Humboldt, Mendocino, and Trinity counties (Ferguson 2019). Small-scale illegal cannabis farms have operated in this area since at least the 1960s but have expanded rapidly since the passage of the Compassionate Use Act in 1996, particularly trespass grows on public land primarily by Mexican cartels (Mallery 2010, Bauer et al. 2015). Like other forms of agriculture, it involves clearing the land, diverting water, and using herbicides and pesticides; however, in addition, many of these illicit operations use large quantities of fertilizers and highly toxic banned pesticides to kill anything that may threaten the crop, and they leave substantial amounts of non-biodegradable trash and human excrement (Mallery 2010, Thompson et al. 2014, Carah et al. 2015).

Measurements of environmental impacts of illegal cannabis grows have been hindered by the difficult and dangerous nature of accessing many of these sites; however, some analyses have been conducted, often using aerial images and GIS. An evaluation of 54% of watersheds within and bordering Humboldt County revealed that while cannabis grow sites are generally small (<1.2 ac) and comprised a tiny fraction of the study area (301 ac), they were widespread (present in 83% of watersheds) but unevenly distributed, indicating impacts are concentrated in certain watersheds (Butsic and Brenner 2016, Wang et al. 2017). The results also showed that 68% of grows were ≤0.3 mi from developed roads, 23% were located on slopes steeper than 30%, and 5% were within 328 ft of critical habitat for threatened salmonids (Butsic and Brenner 2016). These characteristics suggest wildlands adjacent to cannabis cultivations are at heightened risk of habitat fragmentation, erosion, sedimentation, landslides, and impacts to waterways critical to imperiled species (Ibid.).

A separate analysis in the same general area estimated potentially significant impacts from water diversions alone. Cannabis requires a substantial amount of water during the growing season, so it is often cultivated near sources of perennial surface water for irrigation, commonly diverting from springs and headwater streams (Bauer et al. 2015). In the least impacted of the study watersheds, Bauer et al. (2015) calculated that diversions for cannabis cultivation could reduce the annual seven-day low flow by up to 23%, and in some of the heavily impacted watersheds, water demands for cannabis could exceed surface water availability. If not regulated carefully, cannabis cultivation could have substantial impacts on sensitive aquatic species like Foothill Yellow-legged Frogs in watersheds in which it is concentrated.

For context, cannabis cultivation was responsible for approximately 1.1% of forest cover lost within study watersheds in Humboldt County from 2000 to 2013, while timber harvest accounted for 53.3% (Wang et al. 2017). Cannabis requires approximately two times as much water per day as wine grapes, the other major irrigated crop in the region (Bauer et al. 2015). Impacts from cannabis cultivation have been observed by Foothill Yellow-legged Frog researchers working on the Trinity River and South Fork Eel River in the form of lower flows in summer, increased egg stranding, and more algae earlier in the season in recent years (S. Kupferberg and M. Power pers. comm. 2015; D. Ashton pers. comm. 2017; S. Kupferberg, M. van Hattem, and W. Stokes pers. comm. 2017). In addition, Gonsolin (2010) reported illegal cannabis cultivations on four headwater streams that drained into his study area along Coyote Creek, three of which were occupied by Foothill Yellow-legged Frogs. The cultivators had removed vegetation adjacent to the creeks, terraced the slopes, diverted water, constructed small water impoundments, poured fertilizers directly into the impoundments, and applied herbicides and pesticides, as evidenced by leftover empty containers littering the site.

Commercial sale of cannabis for recreational use became legal in California on January 1, 2018, through passage of the Control, Regulate and Tax Adult Use of Marijuana Act (2016), and with it an environmental permitting system and habitat restoration fund was established. The number of applications for temporary licenses per watershed is depicted in Figure 24. Two of the expected outcomes of passage of this law were that the profit-margin on growing cannabis would fall to the point that it would discourage illegal trespass grows and move the bulk of the cultivation out of remote forested areas into existing agricultural areas like the Central Valley (CSOS 2016). However, until cannabis is legalized at the federal level, these results may not occur since banks are reluctant to work with growers due to federal prohibitions subjecting them to prosecution for money laundering (ABA 2019). Additional details on cannabis permitting at the state level can be found under the Existing Management section.

4.6.3 Vineyards

Vineyard operators historically built on-stream dams and removed almost all the surrounding riparian vegetation to make room for vines and for ease of irrigation (M. van Hattem pers. comm. 2019). They still divert a substantial amount of water for irrigation, and they build on- and off-stream impoundments that support bullfrogs (Ibid.). The acreage of land planted in wine grapes in California began rising dramatically in the 1970s and now accounts for 90% of wine produced in the U.S. (Geisseler and Horwath 2016, Alston et al. 2018). The number of wineries in California rose from approximately 330 to

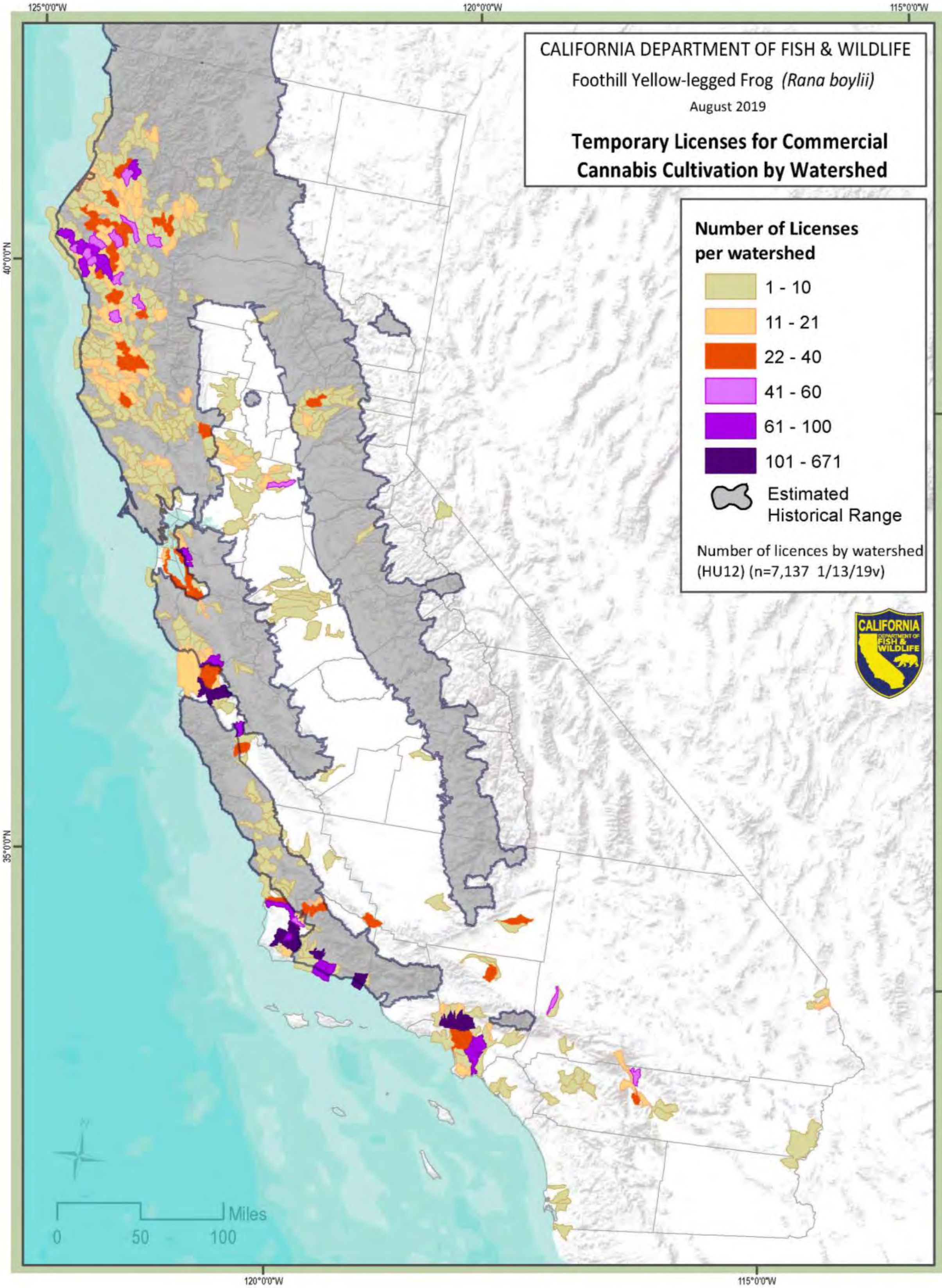


Figure 24. Cannabis cultivation temporary licenses by watershed in California (CDFA, NHD)

nearly 2,500 between 1975 and 2006; however, expansion slowed and has reversed slightly recently with 60,000 ac, or 6.5% of total area planted, removed between 2015 and 2017 (Volpe et al. 2010, CDFA 2018b). In 2015, 857,000 ac were planted in grapes with 70% located in the San Joaquin Valley; 66%, 21%, and 13% were planted in wine, raisin, and table grapes, respectively (Alston et al. 2018).

Expansion of wineries in the coastal counties converted natural areas such as oak woodlands and forests to vineyards (Merenlender 2000, Napa County 2010). The area of Sonoma County covered in grapes increased by 32% from 1990 to 1997, and 42% of these new vineyards were planted above 328 ft with 25% on slopes greater than 18% (Merelender 2000). For context, only 18% of vineyards planted before 1990 occurred above 328 ft and less than 6% on slopes greater than 18% (Ibid.). This conversion took place on approximately 1,909 ac of conifer and dense hardwood forest, 7,229 ac of oak grassland savanna, and 367 ac of shrubland (Ibid.). Recent expansion of oak woodland conversion to vineyards in Napa County was highest in its eastern hillsides (Napa County 2010). Napa County estimates that between 2,682 and 3,065 ac of woodlands will be converted to vineyards between 2005 and 2030 (Ibid.). For context, 733 ac were converted from 1992 to 2003 (Ibid.). In addition, wine grapes were second only to almonds in terms of overall quantity of pesticides applied in California in 2016, but the quantity per unit area 2.6 lb/ac was 160% greater for the wine grapes (CDPR 2018). Vineyard expansion into hillsides has continued into sensitive headwater areas, and like cannabis cultivation, even small vineyards can have substantial impacts on Foothill Yellow-legged Frog habitat through sedimentation, water diversions, spread of harmful non-native species, and agrochemical contamination (Merelender 2000, K. Weiss pers. comm. 2018).

4.6.4 Livestock Grazing

Livestock grazing can be an effective habitat management tool, including control of riparian vegetation encroachment into important Foothill Yellow-legged Frog breeding habitat, but overgrazing can significantly degrade the environment (Siekert et al. 1985). Cattle display a strong preference for riparian areas and have been implicated as a major source of habitat damage in the western U.S., where the adverse impacts of overgrazing on riparian vegetation are intensified by arid and semi-arid climates (Behnke and Raleigh 1978, Kauffman and Krueger 1984, Belsky et al. 1999). The severity of grazing impacts on riparian systems can be influenced by the number of animals, duration and time of year, substrate composition, and soil moisture (Benhke and Raleigh 1978, Kauffman et al. 1983, Marlow and Pogacnik 1985, Siekert et al. 1985). In addition to habitat damage, cattle can directly trample any life stage of Foothill Yellow-legged Frog.

Signs of overgrazing include impacts to the streambanks such as increased slough-offs and cave-ins that collapse undercuts used as refuge by Foothill Yellow-legged Frogs (Kauffman et al. 1983). Overgrazing reduces riparian cover and increases erosion and sedimentation, which as described above can result in silt degradation of breeding, rearing, and invertebrate food-producing areas (Cordone and Kelley 1961, Behnke and Raleigh 1978, Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). Loss of streamside and instream vegetative cover and changes to channel morphology can increase water temperatures and velocities (Behnke and Raleigh 1978). Water quality can be affected by increased turbidity and nutrient input from excrement, and seasonal water quantity can be impacted through changes to channel morphology (Belsky et al. 1999). In addition, increased nutrients and temperatures can promote blooms of harmful cyanobacteria like *Microcystis aeruginosa*, which releases a toxin when it expires that can cause liver damage to amphibians as well as other animals including humans (Bobzien and DiDonato 2007, Zhang et al. 2013).

While some recent studies indicate livestock grazing continues to damage stream and riparian ecosystems, its impact on Foothill Yellow-legged Frogs in California is unknown (Belsky et al. 1999, Hayes et al. 2016). In Oregon, the species' presence was correlated with significantly less grazing than where they were absent according to Borisenko and Hayes's 1999 report (as cited in Olson and Davis 2009). However, Fellers (2005) reported that apparently some Coast Range foothill populations occupying streams draining east into the San Joaquin Valley were doing well at the time of publication despite being heavily grazed.

4.7 Urbanization and Road Effects

Habitat conversion and fragmentation combined with modified environmental disturbance regimes can substantially jeopardize biological diversity (Tracey et al. 2018). This threat is most severe in areas like California with Mediterranean-type ecosystems that are biodiversity hot spots, fire-prone, and heavily altered by human land use (Ibid.). From 1990 to 2010, the fastest-growing land use type in the conterminous U.S. was new housing construction, which rapidly expanded the wildland-urban interface (WUI), where houses and natural vegetation meet or intermix on the landscape (Radeloff et al. 2018).

Of several variables tested, proportion of urban land use within a 3.1 mi radius of a site was associated with Foothill Yellow-legged Frog declines (Davidson et al. 2002). Lind (2005) also found significantly less urban development nearby and upwind of sites occupied by Foothill Yellow-legged Frogs, suggesting pollutant drift may be a contributing factor. Changes in wildfires may also contribute to the species' declines; 95% of California's fires are human-caused, and wildfire issues are greatest at the WUI (Syphard et al. 2009, Radeloff et al. 2018). Population density, intermix WUI (where wildland and development intermingle as opposed to an abrupt interface), and distance to WUI explained the most variability in fire frequency (Syphard et al. 2007). In addition to wildfires, habitat loss, and fragmentation, urbanization can impact adjacent ecosystems through non-native species introduction, native predator subsidization, and disease transmission (Bar-Massada et al. 2014).

Projections show growth in California's population to 51 million people by 2060, from approximately 40 million currently (PPIC 2019). This will increase urbanization, the WUI, and habitat fragmentation. The Department of Finance projects the Inland Empire, the San Joaquin Valley, and the Sacramento metropolitan area will be the fastest-growing regions of the state over the next several decades (Ibid.). This puts the greatest pressure in areas outside of the Foothill Yellow-legged Frog's range; however, because the environmental stressors associated with urbanization can span far beyond its physical footprint, they may still adversely affect the species.

Highways are frequently recognized as barriers to dispersal that fragment habitats and populations; however, single-lane roads can pose significant risks to wildlife as well (Cook et al. 2012, Brehme et al. 2018). Foothill Yellow-legged Frogs are at risk of being killed by vehicles when roads are located near their habitat (Cook et al. 2012, Brehme et al. 2018). Fifty-six juvenile Foothill Yellow-legged Frogs were found on a road adjacent to Sulphur Creek (Mendocino County), seven of which had been struck and killed (Cook et al. 2012). When fords (naturally shallow areas) are used as vehicle crossings, they can create sedimentation and poor water quality, and when the fords are gravel or cobble bars used by Foothill Yellow-legged Frogs for breeding, their use could result in direct mortality (K. Blanchard pers. comm. 2018, R. Bourque pers. comm. 2018).

Construction of culverts under roads to keep vehicles out of the streambed can result in varying impacts. In some cases, they can impede dispersal, trap frogs, and create deep scoured pools that support predatory fish and frogs, but when properly constructed, they can facilitate frog movement up and down the channel with reduced road mortality (Van Wagner 1996, GANDA 2008, C. Dillingham pers. comm. 2019). In addition, those scoured pools can provide habitat for Foothill Yellow-legged Frogs in areas where premature drying is a threat and non-native species are absent (M. Grefsrud pers. comm. 2019). Culverts can also act in a similar way to a natural waterfall and impede upstream migration of non-native fish and crayfish (Kerby et al. 2005). An evaluation of the relative impact of roads on 166 native California amphibians and reptiles, through barriers to movement and direct mortality, concluded that Foothill Yellow-legged Frogs, at individual and population levels, were at moderate risk in aquatic habitat but very low risk of impacts in terrestrial habitat (Brehme et al. 2018). For context, all chelonids (turtles and tortoises), 72% of snakes, 50% of anurans, 18% of lizards, and 17% of salamander species in California were ranked as having a high or very high risk of negative road impacts in the same evaluation (Ibid.).

Poorly constructed roadways near rivers and streams can result in substantial erosion and sedimentation, leading to reduced amphibian densities (Welsh and Ollivier 1998). Proximity of roads to Foothill Yellow-legged Frog habitat contributes to petrochemical runoff and poses the threat of spills (Ashton et al. 1997). A diesel spill on Hayfork Creek (Trinity County) resulted in mass mortality of Foothill Yellow-legged Frog tadpoles and partial metamorphs (Bury 1972). Roads have also been implicated in the spread of disease and may have aided in the spread of Bd in California (Adams et al. 2017b).

Frogs use auditory and visual cues to defend territories and attract mates, and some studies reveal that realistic levels of traffic noise can impede transmission and reception of these signals (Bee and Swanson 2007). Some male frogs have been observed changing the frequency of their calls to increase the distance they can be heard over traffic noise, but if females have evolved to recognize lower pitched calls as signs of superior fitness, this potential trade-off between audibility and attractiveness could have implications for reproductive success (Parris et al. 2009). In a separate study, traffic noise caused a change in male vocal sac coloration and an increase in stress hormones, which changed sexual selection processes and suppressed immunity (Troïanowski et al. 2017). Because Foothill Yellow-legged Frogs mostly call underwater and are not known to use color displays, communication cues may not be adversely affected by traffic noise, but their stress response is unknown.

4.8 Timber Harvest

Because Foothill Yellow-legged Frogs tend to remain close to the water channel (i.e., within the riparian corridor) and current timber harvest practices minimize disturbance in riparian areas for the most part, adverse effects from timber harvest are expected to be relatively low (Hayes et al. 2016, CDFW 2018b). However, some activities have a potential to negatively impact Foothill Yellow-legged Frogs or their habitat, including direct mortality and increased sedimentation during construction and decommissioning of watercourse crossings and infiltration galleries, tree felling, log hauling, and entrainment by water intakes or desiccation of eggs and tadpoles through stranding from dewatering during drafting operations (CDFW 2018b,c). In addition to impacts previously described under the Sedimentation and Urbanization and Road Effects sections, when silt runoff into streams is accompanied by organic materials, such as logging debris, impaired water quality can result, including reduced dissolved oxygen, which is important in embryonic and tadpole development (Cordone and Kelley 1961).

Because Foothill Yellow-legged Frogs are heliotherms (i.e, they bask in the sun to raise their body temperature) and sensitive to thermal extremes, some moderate timber harvest may benefit the species (Zweifel 1955, Fellers 2005). Ashton (2002) reported 85% of his Foothill Yellow-legged Frog observations occurred in second-growth forests (37-60 years post-harvest) as opposed to late-seral forests and postulated that the availability of some open canopy areas played a major part in this disparity. Foothill Yellow-legged Frogs are typically absent in areas with closed canopy (Welsh and Hodgson 2011). Reduced canopy also raises stream temperatures, which could improve tadpole development and promote algal and invertebrate productivity in otherwise cold streams (Olson and Davis 2009; Catenazzi and Kupferberg 2013,2017).

4.9 Recreation

Several types of recreation can adversely impact Foothill Yellow-legged Frogs, and some are more severe and widespread than others. Increased and intensified recreation in streams was one of the main potential factors identified by herpetologists as contributing to disappearance of Foothill Yellow-legged Frogs in southern California (Adams et al. 2017b). The greater number of people traveling into the backcountry may have facilitated the spread Bd to these areas, and while no evidence shows stress from disturbance or other environmental pressures increases susceptibility to Bd, the stress hormone corticosterone has been implicated in immunosuppression (Hayes et al. 2003, Adams et al. 2017b).

The amount of Foothill Yellow-legged Frog habitat disturbed by off-highway motor vehicles (OHV) throughout its range in California is unknown, but its impacts can be significant, particularly in areas with small isolated populations (Kupferberg et al. 2009c, Kupferberg and Furey 2015). An example is the Carnegie State Vehicular Recreation Area (CSVRA), located in the hills southwest of Tracy in the Corral Hollow Creek watershed (Alameda and San Joaquin counties). The above-described road effects apply: sedimentation, crushing along trail crossings, and potential noise effects (Ibid.). In addition, dust suppression activities employed by CSVRA use magnesium chloride, which has the potential to harm developing embryos and tadpoles (Karraker et al. 2008, Hopkins et al. 2013, OHMVRC 2017). Based on museum records, Foothill Yellow-legged Frogs were apparently abundant in Corral Hollow Creek, but they are extremely rare now and are already extirpated or at risk of extirpation (Kupferberg et al. 2009c, Kupferberg and Furey 2015).

Motorized and non-motorized recreational boating can also impact Foothill Yellow-legged Frogs. The impacts of jet boat traffic were investigated in Oregon; in areas with frequent use and high wakes breaking on shore, Foothill Yellow-legged Frogs were absent (Borisenko and Hayes 1999 as cited in Olson and Davis 2009). This wake action had the potential to dislodge egg masses, strand tadpoles, disrupt adult basking behavior, and erode shorelines (Ibid.). Jet boat tours and races on the Klamath River (Del Norte and Humboldt counties) may have an impact on Foothill Yellow-legged Frog use of the mainstem (M. van Hattem pers. comm. 2019). In addition, using gravel bars as launch and haul out sites for boat trailers, kayaks, or river rafts can result in direct loss of egg masses and tadpoles or damage to breeding and rearing habitat and can disrupt post-metamorphic frog behavior (Ibid.). As described above, pulse flows released for whitewater boating in the late spring and summer can result in scouring and stranding of egg masses and tadpoles (Borisenko and Hayes 1999 as cited in Olson and Davis 2009, Kupferberg et al. 2009b). The nearshore velocities of these pulse flows are greater than those that resulted in stunted growth and increased vulnerability to predation in Foothill Yellow-legged Frog tadpoles under experimental conditions (Kupferberg et al. 2011b).

Hiking, horse-riding, camping, fishing, and swimming, particularly in sensitive breeding and rearing habitat, can also adversely impact Foothill Yellow-legged Frog populations (Borisenko and Hayes 1999 in Olson and Davis 2009). Because Foothill Yellow-legged Frog breeding activity was being disturbed and egg masses were being trampled by people and dogs using Carson Falls (Marin County), the land manager established an educational program, including employing docents on weekends that remind people to stay on trails and tread lightly to try to reduce the loss of Foothill Yellow-legged Frog reproductive effort (Prado 2005). In addition, within his study site, Van Wagner (1996) reported that a property owner moved rocks that were being used as breeding habitat to create a swimming hole. The extent to which this is more than a small, local problem is unknown, but as the population of California increases, recreational pressures in Foothill Yellow-legged Frog habitat are likely to increase commensurately.

4.10 Drought

Drought is a common phenomenon in California and is characterized by lower than average precipitation. Lower precipitation in general results in less surface water, and water availability is critical for obligate stream-breeding species. Even in the absence of drought, a positive relationship exists between precipitation and latitude within the Foothill Yellow-legged Frog's range in California, and mean annual precipitation has a strong influence on Foothill Yellow-legged Frog presence at historically occupied sites (Davidson et al. 2002, Lind 2005). Figure 25 depicts the recent historical annual average precipitation across the state as well as during the most recent drought and how they differ. Southern California is normally drier than northern California, but the severity of the drought was even greater in the south.

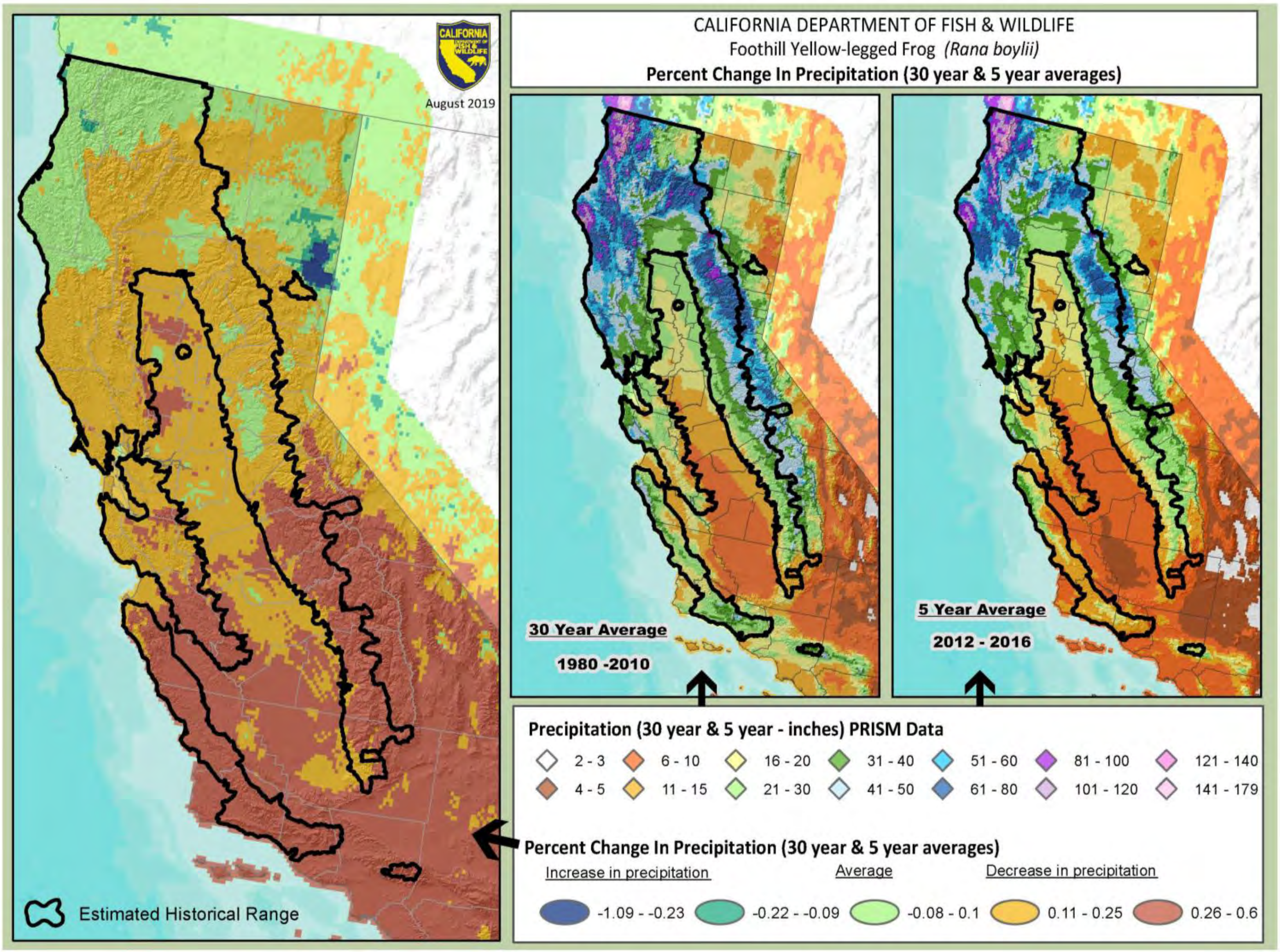


Figure 25. Change in precipitation from recent 30-year average and 5-year drought (PRISM)

Reduced precipitation can result in deleterious effects to Foothill Yellow-legged Frogs beyond the obvious premature drying of aquatic habitat. When stream flows recede during the summer and fall, sometimes the isolated pools that stay perennially wet are the only remaining habitat. This phenomenon concentrates aquatic species, resulting in several potentially significant adverse impacts. Stream flow volume was negatively correlated with Bd load during a recent chytridiomycosis outbreak in the Alameda Creek watershed (Adams et al. 2017a). The absence of high peak flows in winter coupled with wet years allowed bullfrogs to expand their distribution upstream, and the drought-induced low flows in the fall concentrated them with Foothill Yellow-legged Frogs in the remaining drying pools (Ibid.). This mass mortality event appeared to have been the result of a combination of drought, disease, and dam effects (Ibid.). This die-off occurred in a regulated reach that experiences heavy recreational use, and crayfish and bass are present (Ibid.). Despite these threats, the density of breeding females in this reach was greater in 2014 and 2015 than in the unregulated reach upstream because the latter dried completely before tadpoles could metamorphose during the preceding drought years (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015).

In addition to increasing the spread of pathogens, drought-induced stream drying can increase predation and competition by introduced fish and frogs in the pools they are forced to share (Moyle 1973, Hayes and Jennings 1988, Drost and Fellers 1996). This concentration in isolated pools can also result in increased native predation as well as facilitate spread of Bd. An aggregation of six adult Foothill Yellow-legged Frogs was observed perched on a rock above an isolated pool in the summer where a gartersnake was foraging on tadpoles; this close contact may reduce evaporative water loss when they are forced out of the water during high temperatures, but it can also increase disease transmission risk (Leidy et al. 2009.). Gonsolin (2010) also documented a late summer aggregation of juvenile Foothill Yellow-legged Frogs out of water during extremely high temperatures. In addition, drought-induced low flow, high water temperatures, and high densities of tadpoles were associated with outbreaks of malformation-inducing parasitic copepods (Kupferberg et al. 2009a).

Premature stream drying caused or worsened by drought can result in stranding egg masses and tadpoles, but in some situations, it can also benefit Foothill Yellow-legged Frogs. For example, if pools stay wet long enough to support metamorphosis, complete drying at the end of the season may eliminate introduced species like warm water fish and bullfrogs (Bogan et al. 2019). Foothill Yellow-legged Frogs adapted to drought conditions by initiating breeding earlier and shortening the period over which they oviposit (Kupferberg 1996a, Yarnell et al. 2013). Moyle (1973) noted that the only intermittent streams occupied by Foothill Yellow-legged Frogs in the Sierra Nevada foothills had no bullfrogs. At a long-term study site in upper Coyote Creek in early fall 2014, at the height of the most severe drought in over a millennium, remnant pools in the upper watershed provided important refuge for native species (Griffin and Anchokaitis 2014, Bogan et al. 2019). Foothill Yellow-legged Frogs were widely distributed and relatively abundant in the remnant pools, and non-native species were absent in all but one (Bogan et al. 2019). The Foothill Yellow-legged Frog abundance was much lower than reported a decade earlier; it appeared to have never recovered from the 2007-2009 drought (Gonsolin 2010, J. Smith pers. comm. 2015). However, in 2016 after a relatively wet winter, Foothill Yellow-legged

Frogs bred en masse, and only a single adult bullfrog was detected, which was an unusually low number for that area (CDWR 2016, J. Smith pers. comm. 2016).

Drought can also exacerbate the effects of other environmental stressors. During the most recent severe drought, tree mortality increased dramatically from 2014 to 2017 and reached approximately 129 million dead trees (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are more prone to severe wildfires, and they lose their carbon sequestration function while also emitting methane, which is an extremely damaging greenhouse gas (CNRA 2016). Post-wildfire storms can result in erosion of fine sediments from denuded hillsides into the stream channel (Florsheim et al. 2017). If the storms are short in duration and peak discharges are low magnitude, as happens during droughts, flows may be insufficient to transport the material downstream, extending the duration of habitat degradation (Ibid.). Reduced rainfall may also infiltrate the debris leading to subsurface flows rather than the surface water Foothill Yellow-legged Frogs require (Ibid.). Extended droughts increase risk of the stream being uninhabitable or inadequate for breeding for multiple years, which would result in population-level impacts and possible extirpation (Ibid.).

4.11 Wildland Fire and Fire Management

Fire is an important element for shaping and maintaining the species composition and integrity of many California ecosystems (Syphard et al. 2007, SBFFP 2018). Prior to European settlement, an estimated 4.5 to 12 million ac burned annually (4-11% of total area of the state), ignited both deliberately by Native Americans and through lightning strikes (Keeley 2005, SBFFP 2018). The impacts of wildland fires on Foothill Yellow-legged Frogs are poorly understood and likely vary significantly across the species' range with differences in climate, vegetation, soils, stream-order, slope, frequency, and severity (Olson and Davis 2009). Mortality from direct scorching is unlikely because Foothill Yellow-legged Frogs are highly aquatic, and most wildfires occur during the dry period of the year when the frogs are most likely to be in or near the water (Pilliod et al. 2003, Bourque 2008). Field observations support this presumption; sightings of post-metamorphic Foothill Yellow-legged Frogs immediately after fires in the northern Sierra Nevada and North Coast indicate they are not very vulnerable to the direct effects of fire (S. Kupferberg and R. Peek pers. comm. 2018). Similarly, Foothill Yellow-legged Frogs were observed two months, and again one year, after a low- to moderate-intensity fire burned an area in the southern Sierra Nevada in 2002, and the populations were extant and breeding as recently as 2017 (Lind et al. 2003b, CNDDB 2019). While water may provide a refuge from fire, it is also possible for temperatures during a fire, or afterward due to increased solar exposure, to near or exceed a threshold that results in lethal or sublethal harm; this would likely impact embryos and tadpoles with limited dispersal abilities (Pilliod et al. 2003).

Intense fires remove overstory canopy, which provides insulation from extreme heat and cold, and woody debris that increases habitat heterogeneity (Pilliod et al. 2003, Olson and Davis 2009). If this happens frequently enough, it can permanently change the landscape. For example, frequent high-severity burning of crown fire-adapted ecosystems can prevent forest regeneration since seeds require sufficient time between fires to mature, and repeated fires can deplete the seed bank (Stephens et al.

2014). Smoke and ash change water chemistry through increased nutrient and heavy metal inputs that can reach concentrations harmful to aquatic species during the fire and for days, weeks, or years thereafter (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Erosion rates on granitic soils, which make up a large portion of the Foothill Yellow-legged Frog's range, can be over 60 times greater in burned vs. unburned areas and can increase sedimentation for over 10 years (Megahan et al. 1995, Hayes et al. 2016). In some cases, post-fire nutrient inputs into streams could benefit Foothill Yellow-legged Frogs through increased productivity and more rapid growth and development (Pilliod et al. 2003). While the loss of leaf litter that accompanies fire alters the food web, insects are expected to recolonize rapidly, and the lack of cover could increase their vulnerability to predation by Foothill Yellow-legged Frogs (Ibid.).

Low-intensity fires likely have no adverse effect on Foothill Yellow-legged Frogs (Olson and Davis 2009). If they occur in areas with dense canopy, wildfires can improve habitat quality for Foothill Yellow-legged Frogs by reducing riparian cover, providing areas to bask, and increasing habitat heterogeneity, which is likely to outweigh any adverse effects from some fire-induced mortality (Russell et al. 1999, Olson and Davis 2009). In a preliminary analysis of threats to Foothill Yellow-legged Frogs in Oregon, proximity to stand-replacing fires was not associated with absence (Olson and Davis 2009).

Euro-American colonization of California significantly altered the pattern of periodic fires with which California's native flora and fauna evolved through fire exclusion, land use practices, and development (OEHHA 2018). Fire suppression can lead to canopy closure, which reduces habitat quality by limiting thermoregulatory opportunities (Olson and Davis 2009). In addition, fire suppression and its subsequent increase in fuel loads combined with expanding urbanization and rising temperatures have resulted in a greater likelihood of catastrophic stand-replacing fires that can significantly alter riparian systems for decades (Pilliod et al. 2003). Firebreaks, in which vegetation is cleared from a swath of land, can result in similar impacts to roads and road construction (Ibid.). Fire suppression can also include bulldozing within streams to create temporary reservoirs for pumping water, which can cause more damage than the fire itself to Foothill Yellow-legged Frogs in some cases (S. Kupferberg and R. Peek pers. comm. 2018). In addition, fire suppression practices can involve applying hundreds of tons of ammonia-based fire retardants and surfactant-based fire suppressant foams from air tankers and fire engines (Pilliod et al. 2003). Some of these chemicals are highly toxic to some anurans (Little and Calfee 2000).

Fire suppression has evolved into fire management with a greater understanding of its importance in ecosystem health (Keeley and Syphard 2016). Several strategies are employed including prescribed burns, mechanical fuels reduction, and allowing some fires to burn instead of extinguishing them (Pilliod et al. 2003). Like wildfires themselves, fire management strategies have the potential to benefit or harm Foothill Yellow-legged Frogs. Prescribed fires and mechanical fuels removal lessen the likelihood of catastrophic wildfires, but they can also result in loss of riparian vegetation, excessive sedimentation, and increased water temperatures (Ibid.). Salvage logging after a fire may result in similar impacts to timber harvest but with higher rates of erosion and sedimentation (Ibid.). A balanced approach to wildland fires is likely to have the greatest beneficial impact on species and ecosystem health (Stephens et al. 2012).

4.12 Floods and Landslides

As previously described, Foothill Yellow-legged Frog persistence is highly sensitive to early life stage mortality (Kupferberg et al. 2009c). While aseasonal dam releases are a major source of egg mass and tadpole scouring, storm-driven floods are also capable of inducing the same effects (Ashton et al. 1997). Van Wagner (1996) concluded that the high discharge associated with heavy rainfall could account for a significant source of mortality in post-metamorphic Foothill Yellow-legged Frogs as well as eggs and tadpoles; he observed two adult females and several juveniles swept downstream with fatal injuries post-flooding. Severe flooding, specifically two 500-year flood events in early 1969 in Evey Canyon (Los Angeles County), resulted in massive riparian habitat destruction (Sweet 1983). Prior to the floods, Foothill Yellow-legged Frogs were widespread and common, but only four subsequent sightings were documented between 1970 and 1974 and none since (Sweet 1983, Adams 2017b). Sweet (1983) speculates that because Foothill Yellow-legged Frogs overwinter in the streambed in that area, the floods may have reduced the population's abundance below an extinction threshold. Four other herpetologists interviewed about Foothill Yellow-legged Frog extirpations in southern California listed severe flooding as a likely cause (Adams et al. 2017b).

As mentioned above, landslides are a frequent consequence of post-fire rainstorms and can result in lasting impacts to stream morphology, water quality, and Foothill Yellow-legged Frog populations. On the other hand, Olson and Davis (2009) suggest that periodic landslides can have beneficial effects by transporting woody debris into the stream that can increase habitat complexity and replace sediments that are typically washed downstream over time. Whether a landslide is detrimental or beneficial is likely heavily influenced by amount of precipitation and the underlying system. As previously described, too little precipitation could lead to prolonged loss of habitat through failure to transport material downstream, and too much precipitation can result in large-scale habitat destruction and direct mortality.

4.13 Climate Change

Foothill Yellow-legged Frogs evolved over millions of years through repeated droughts, flooding, and fires, but relatively recent anthropogenic habitat fragmentation and degradation have reduced the species' ability to recolonize sites where they have been extirpated by these events. Cumulatively, the threats and stressors Foothill Yellow-legged Frogs encounter over much of their range in California jeopardize their persistence in currently occupied areas. Climate change is expected to exacerbate many of these impacts.

Global climate change threatens biodiversity and may lead to increased frequency and severity of drought, wildfires, flooding, and landslides (Williams et al. 2008, Keely and Syphard 2016). Data show a consistent trend of warming temperatures in California and globally; 2014 was the warmest year on record, followed by 2015, 2017, and 2016 (OEHHA 2018). Climate model projections for annual temperature in California in the 21st century range from 2.7 to 8.1°F greater than the 1961-1990 mean (Cayan et al. 2008). Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation and increasingly dry conditions in California resulting from increased evaporative water loss primarily due to rising temperatures (Cayan et al. 2005, Williams et al. 2015, OEHHA 2018). Precipitation variability and proportion of dry years were negatively associated with Foothill Yellow-legged Frog presence in a range-wide analysis (Lind 2005). In addition, low precipitation intensified the adverse effects of dams on the species (Ibid.).

California recently experienced the longest drought since the U.S. Drought Monitor began reporting in 2000 (NIDIS 2019). Figure 26 depicts that California experienced drought effects in at least a portion of the state for 376 consecutive weeks until it broke on March 5, 2019 (Ibid.). The most intense period occurred during the week of October 28, 2014 when D4 (the most severe drought category) affected 58.4% of California's land area (Ibid.). A recent modeling effort using data on historical droughts, including the Medieval megadrought between 1100 and 1300 CE, indicates the mean state of drought from 2050 to 2099 in California will likely exceed the Medieval-era drought, under both high and moderate greenhouse gas emissions models (Cook et al. 2015). The probability of a multidecadal (35 yr) drought occurring during the late 21st century is greater than 80% in all models used by Cook et al. (2015). If correct, this would represent a climatic shift that not only falls outside of contemporary variability in aridity but would also be unprecedented in the past millennium (Ibid.).

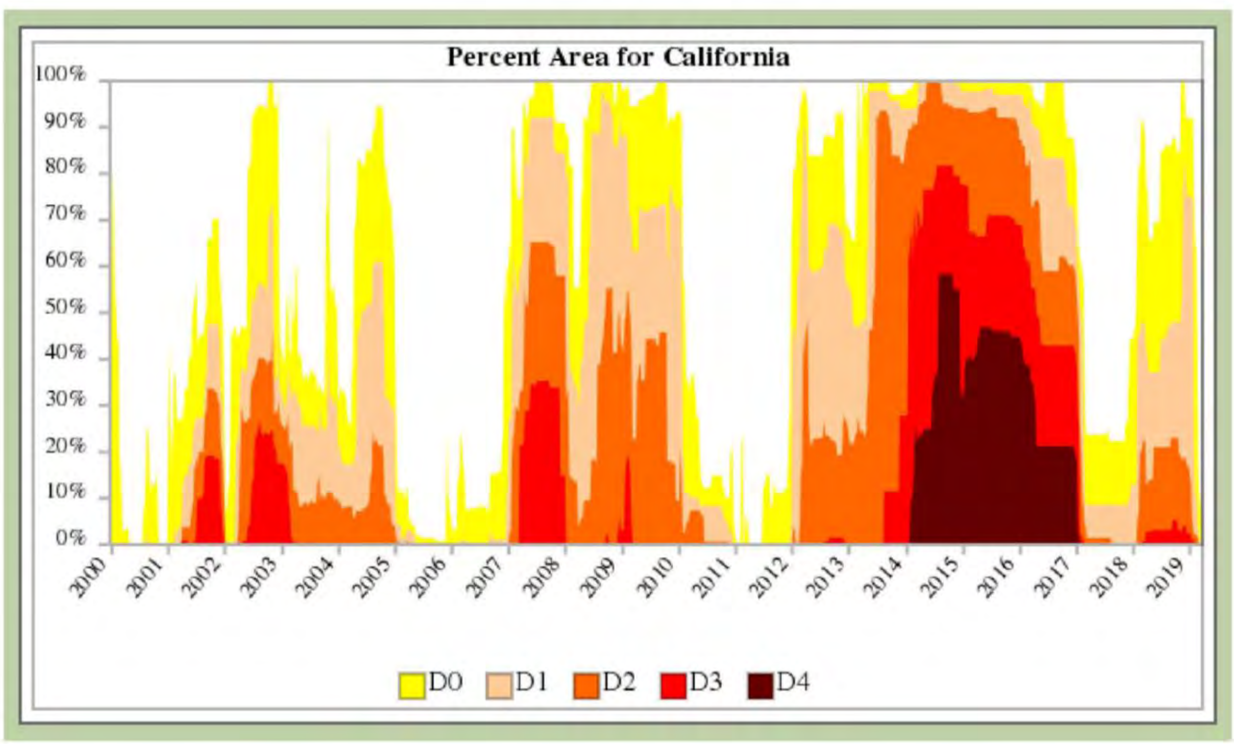


Figure 26. Palmer Hydrological Drought Indices 2000-2019 (NIDIS)

As a result of increasing temperatures, a decreasing proportion of precipitation falls as snow, resulting in more runoff from rainfall during the winter and a shallower snowpack that melts more rapidly (Stewart 2009). A combination of reduced seasonal snow accumulation and earlier streamflow timing significantly reduces surface water storage capacity and increases the risk for winter and spring floods, which may require additional and taller dams and alterations hydropower generation flow regimes

(Cayan et al. 2005, Knowles et al. 2006, Stewart 2009). The reduction in snowmelt volume is expected to impact the northern Sierra (Feather, Yuba, and American River watersheds) to a greater extent than the southern portion (Young et al. 2009). The earlier shift in peak snowmelt timing is predicted to exceed four to six weeks across the entire Sierra Nevada, depending on the amount of warming that occurs this century (Ibid.). In addition, the snow water equivalent is predicted to significantly decline by 2070-2099 over the 1961-1990 average in the Trinity, Sacramento, and San Joaquin drainages from -32% to -79%, and effectively no snow is expected to fall below 3,280 ft in the high emissions/sensitive model (Cayan et al. 2008).

The earlier shift of snowmelt and lower water content will result in lower summer flows, which will intensify the competition for water among residential, agricultural, industrial, and environmental needs (Field et al. 1999, Cook et al. 2015). In unregulated systems, as long as water is present through late summer, an earlier hydrograph recession that triggers Foothill Yellow-legged Frog breeding could result in a longer time to grow larger prior to metamorphosis, which is expected to improve survival (Yarnell et al. 2010, Kupferberg 2011b). However, if duration from peak to base flow shortens, it can result in increased sedimentation and reduced habitat complexity in addition to stranding (Yarnell et al. 2010).

Fire frequency relates to temperature, fuel loads, and fuel moisture (CCSP 2008). Therefore, increasing periods of drought combined with extreme heat and low humidity that stress or kill trees and other vegetation create ideal conditions for wildland fires (Ibid). Not surprisingly, the area burned by wildland fires over the western U.S. increased since 1950 but rose rapidly in the mid-1980s (Westerling et al. 2006, OEHHA 2018). As temperatures warmed and snow melted earlier, large-wildfire frequency and duration increased, and wildfire seasons lengthened (Westerling et al. 2006, OEHHA 2018). With increased fire frequency comes the heightened risk of landslides and extended periods of habitat unsuitability.

In California, latitude is inversely correlated with temperature and annual area burned, but the climate-fire relationship is substantially different across the state, and future wildfire regimes are difficult to predict (Keeley and Syphard 2016). For example, the relationship between spring and summer temperature and area burned in the Sierra Nevada is highly significant but not in southern California (Ibid.). Climate has a greater influence on fire regimes in mesic environments than arid, and the most influential climatological factor (e.g., precipitation, temperature, season, or their interactions) shifts over time (Ibid.). Nine of the 10 largest fires in California since 1932 have occurred in the past 20 years, four within the past two years (Figure 27; CAL FIRE 2019). However, it is possible this trend will not continue; climate- and wildfire-induced changes in vegetation could reduce wildfire severity in the future (Parks et al. 2016).

Wildfires themselves can accelerate the effects of climate change. Wildfires emit short-lived climate pollutants like black carbon (soot) and methane that are tens to thousands of times greater than carbon dioxide (the main focus of greenhouse gas reduction) in terms of warming effect and are responsible for 40% or more of global warming to date (CNRA 2016). Healthy forests can sequester large amounts of carbon from the atmosphere, but recently carbon emissions from wildfires have exceeded their uptake by vegetation in California (Ackerly et al. 2018).

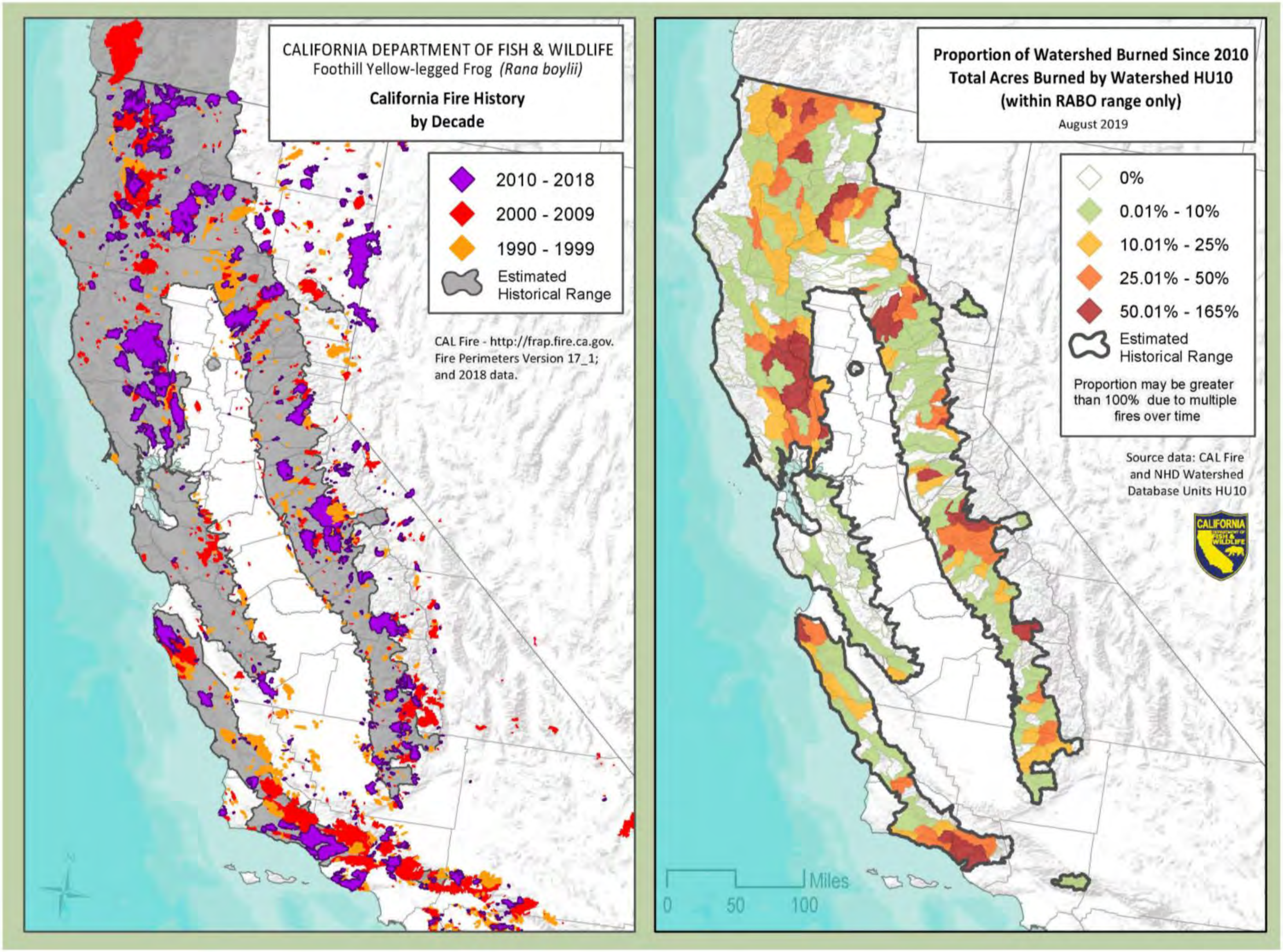


Figure 27. Fire history (1990-2018) and proportion of watershed burned (2010-2018) in California (CAL FIRE, NHD)

With increased variability and changes in precipitation type, magnitude, and timing comes more variable and extreme stream flows (Mallakpour et al. 2018). Models for stream flow in California project higher high flows, lower low flows, wetter rainy seasons, and drier dry seasons (Ibid.). The projected water cycle extremes are related to strengthening El Niño and La Niña events, and both severe flooding and intense drought are predicted to increase by at least 50% by the end of the century (Yoon et al. 2015). These changes increase the likelihood of Foothill Yellow-legged Frog egg mass and tadpole scouring and stranding. However, the severity of these phenomena will vary because an area's underlying geology and lithology affect subsurface water storage capacity, which influences base flows and the degree to which these more frequent extreme weather events will impact Foothill Yellow-legged Frogs (S. Kupferberg pers. comm. 2019). For instance, springs can provide persistent water and a buffer against some drought effects, and areas with low subsurface storage capacity are less affected by changes in rainfall (Hahm et al. 2019, S. Kupferberg pers. comm. 2019).

A species' vulnerability to climate change is a function of its sensitivity to climate change effects, its exposure to them, and its ability to adapt its behaviors to survive with them (Dawson et al. 2011). Myriad examples exist of species shifting their geographical distribution toward the poles and higher elevations as well as changing their growth and reproduction with increases in temperature over time (Parmesan and Yohe 2003, Moritz et al. 2008). However, in many places, fragmentation of suitable habitat by anthropogenic barriers (e.g., urbanization, agriculture, and reservoirs) limits a species' ability to shift its range (Pounds et al. 2007). The proportion of sites historically occupied by Foothill Yellow-legged Frogs that are now extirpated increases significantly on a north-to-south latitudinal gradient and at drier sites within California, suggesting climate change may contribute to the spatial pattern of the species' declines (Davidson et al. 2002).

An analysis of the climate change sensitivity of 195 species of plants and animals in northwestern North America revealed that, as a group, amphibians and reptiles were estimated to be the most sensitive (Case et al. 2015). Nevertheless, examples exist of amphibians adjusting their breeding behaviors (e.g., calling and migrating to breeding sites) to occur earlier in the year as global warming increases (Beebee 1995, Gibbs and Breisch 2001). Because of the rapid change in temperature, Beebee (1995) posits these are examples of behavioral and physiological plasticity rather than natural selection. However, for species with short generation times or in areas less affected by climate change, populations may be able to undergo evolutionary adaptation to the changing local environmental conditions (Hoffman and Sgrò 2011).

As previously described in the Seasonal Activity and Movements section, Foothill Yellow-legged Frog breeding is closely tied to water temperature, flow, and stage, and the species already adjusts its timing of oviposition by as much as two months in the same location during different water years, so the species may have enough inherent flexibility to reduce their vulnerability to predicted climate changes. The species appears fairly resilient to drought, fire, and flooding, at least in some circumstances. For example, after the 2012-2016 drought, the Loma Fire in late 2016, and severe winter flooding and landslides in 2016 and 2017, Foothill Yellow-legged Frog adults and metamorphs, as well as aquatic insects and rainbow trout, were abundant throughout Upper Llagas Creek in fall of 2017, and the substrate consisted of generally clean gravels and cobbles with only a slight silt coating in some pools (J.

Smith pers. comm. 2017). The frogs and fish likely took refuge in a spring-fed pool, and the heavy rains scoured the fine sediments that eroded downstream (Ibid.). These refugia from the effects of climate change reduce the species' exposure, thereby reducing their vulnerability (Case et al. 2015).

Climate change models that evaluate the Foothill Yellow-legged Frog's susceptibility from a species and habitat perspective yield mixed results. An investigation into the possible effects of climate on California's native amphibians and reptiles used ecological niche models, future climate scenarios, and general circulation models to predict species-specific climatic suitability in 2050 (Wright et al. 2013). The results suggested approximately 90-100% of localities currently occupied by Foothill Yellow-legged Frogs are expected to remain climatically suitable in that time, and the proportion of currently suitable localities predicted to change ranges from -20% to 20% (Ibid.). However, a second study, performed by the same research team using a subset of these models, found that 66.4% of currently occupied cells will experience reduced environmental suitability in 2050 (Warren et al. 2014). This analysis included 90 species of native California mammals, birds, reptiles, and amphibians. For context, over half of the taxa were predicted to experience >80% reductions, a consistent pattern reflected across taxonomic groups (Ibid.). Similarly, a third examination, using comparable methods but focusing on the Plumas National Forest (primarily Plumas County with portions of Butte and Sierra counties), found that most of the area will be of the lowest climatic suitability (least and low, in this study) for Foothill Yellow-legged Frogs by 2070 and that each future climate scenario was significantly different from the current model (Bedwell 2018).

A fourth analysis investigated the long-term risk of climate change by modeling the relative environmental stress a vegetative community would undergo in 2099 given different climate and greenhouse gas emission scenarios (Thorne et al. 2016). This model does not incorporate any Foothill Yellow-legged Frog-specific data; it strictly projects climatic stress levels vegetative communities would experience within the species' range boundaries (Ibid.). Unsurprisingly, higher emissions scenarios resulted in a greater proportion of habitat undergoing climatic stress (Figure 28). Perhaps counterintuitively, the warm and wet scenario resulted in a greater amount of stress than the hot and dry scenario. When high emissions and warm and wet changes are combined, a much greater proportion of the vegetation communities will experience "non-analog" conditions, those outside of the range of conditions currently known in California (Ibid.).

4.14 Habitat Restoration and Species Surveys

Potential conflicts between managing riverine habitat below dams for both cold water adapted salmonids and Foothill Yellow-legged Frogs was discussed previously. In addition to problems with temperatures and pulse flows, some stream restoration projects aimed at physically creating or improving salmonid habitat can also adversely affect the frogs. For example, boulder deflectors were placed in Hurdygurdy Creek (Del Norte County) to create juvenile steelhead rearing habitat; deflectors change broad, shallow, low-velocity reaches into narrower, deeper, faster reaches preferred by the fish (Fuller and Lind 1992). Foothill Yellow-legged Frogs were documented using the restoration reach as breeding habitat annually prior to placement of the boulders, but no breeding was detected in the following three years, suggesting this project eliminated the conditions the frogs require (Ibid.). At

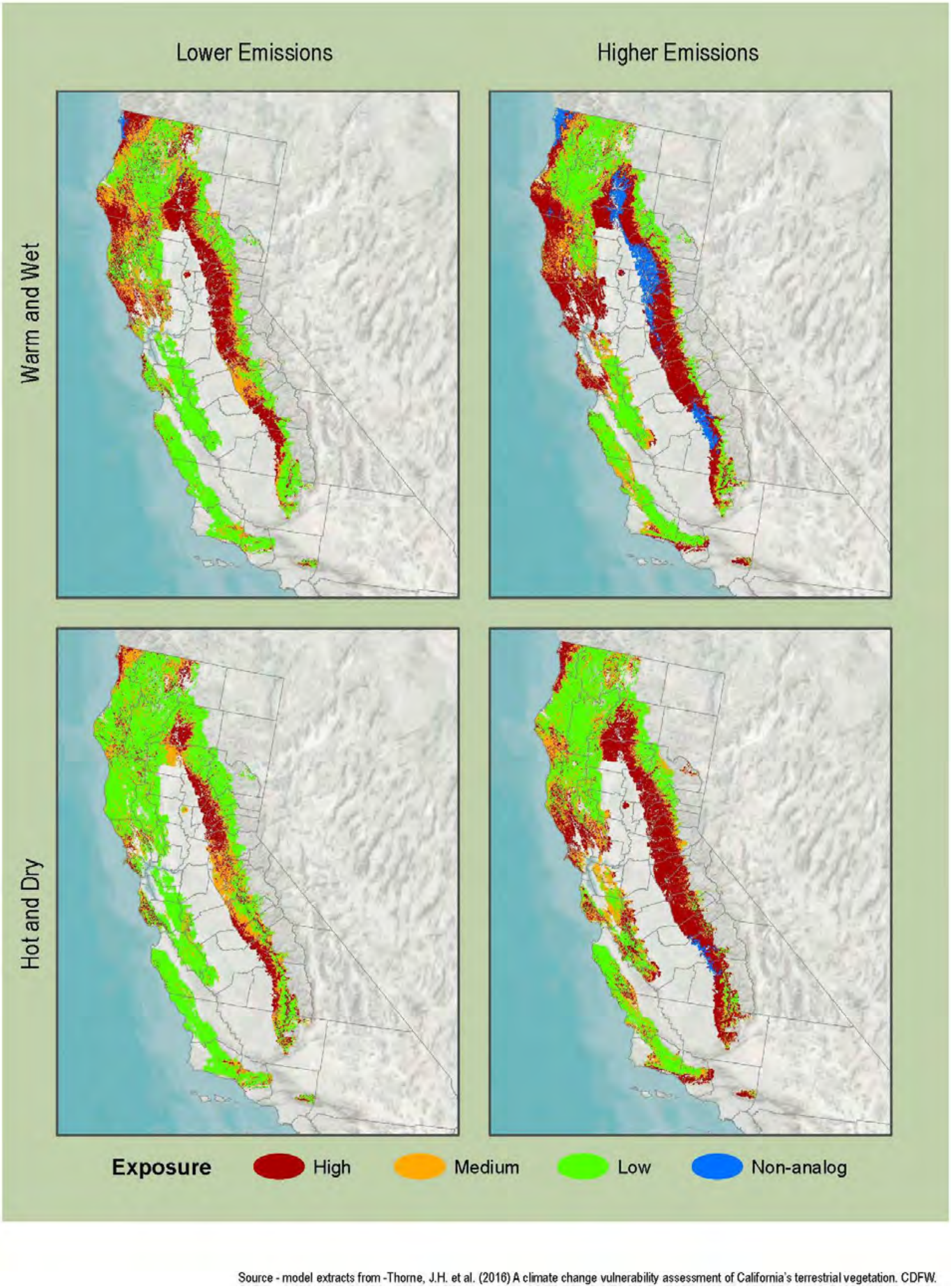


Figure 28. Vegetative community exposure to climate change in 2099 based on Thorne et al. (2016)

another location, a fish passage structure to facilitate salmonid migration above the Alameda Creek Diversion Dam was recently constructed on a Foothill Yellow-legged Frog lek site (M. Grefsrud pers. comm. 2019). The structure blocks a migratory pathway between overwintering habitat in hillside springs and seeps and the creek and creates a potential trap for frogs that fall into the structure (S. Kupferberg pers. comm. 2019). Use of rotenone to eradicate non-native fish as part of a habitat restoration project is rare, but if it is applied in streams occupied by Foothill Yellow-legged Frogs, it can kill tadpoles but is unlikely to impact post-metamorphic frogs (Fontenot et al. 1994). Metamorphosing tadpoles may be able to stay close enough to the surface to breathe air and survive but may display lethargy and experience increased susceptibility to predation (Ibid.).

Commonly when riparian vegetation is removed, regulatory agencies require a greater amount to be planted as mitigation to offset the temporal loss of habitat. This practice can have adverse impacts on habitat suitability for Foothill Yellow-legged Frogs. It is especially problematic where flood suppression by dams has resulted in encroachment into the active channel by riparian trees whose roots bind sediment and steepen the bank slopes (S. Kupferberg pers. comm. 2019). Foothill Yellow-legged Frogs have been observed moving into areas where trees were recently removed, and they are known to avoid heavily shaded areas (Lind et al. 1996, Welsh and Hodgson 2011, M. Grefsrud pers. comm. 2019).

Biologists and other stream researchers can inadvertently harm Foothill Yellow-legged Frogs. When working in Foothill Yellow-legged Frog habitat, in-stream surveyors can trample egg masses or larvae if they are not careful, and those rock-hopping on shore can unknowingly crush post-metamorphic stages that often take cover under streamside rocks (S. Kupferberg pers. comm. 2019). One method for sampling fish is electroshocking, which runs a current through the water that stuns the fish temporarily allowing them to be captured. Post-metamorphic frogs are unlikely to be killed by electroshocking; however, at high frequencies (60 Hz), they may experience some difficulty with muscle coordination for a few days (Allen and Riley 2012). This could increase their risk of predation. At 30 Hz, there were no differences between frogs that were shocked and controls (Ibid.). Tadpoles are more similar to fish in tail musculature and spinal structure and are at higher risk of injuries; however, researchers who reported observing stunned tadpoles noted they appeared to recover completely within several seconds (Ibid.). Adverse effects to Foothill Yellow-legged Frogs from electrofishing may only happen at frequencies higher than those typically used for fish sampling (Ibid.).

4.15 Small Population Sizes

Small populations are at greater risk of extirpation, primarily because the effects of demographic, environmental, and genetic stochasticity are disproportionately greater than they are on large populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). Consequently, any of the threats previously discussed will likely have an even greater adverse impact on small populations of Foothill Yellow-legged Frogs. This risk of extinction from genetic stochasticity is amplified when connectivity between the small populations, and thus gene flow, is impeded (Fahrig and Merriam 1985, Taylor et al. 1993, Lande and Shannon 1996, Palstra and Ruzzante 2008). Genetic diversity provides capacity to evolve in response to environmental changes, and the “rescue effect” of gene flow is important in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). However, the rescue effect is diminished in conditions of high local environmental stochasticity of recruitment or survival (Eriksson et al. 2014). In addition, populations living near their physiological limits and lacking adaptive capacity may not be able to evolve in response to rapid changes (Hoffmann and Sgrò 2011). Furthermore, while pathogens or parasites rarely result in host extinction, they can increase that likelihood in small populations by driving the host populations below a critically low threshold, beneath which demographic stochasticity can lead to extinction, even if they possess the requisite genetic diversity to adapt to a changed environment (Gomulkiewicz and Holt 1995, Adams et al. 2017b).

A Foothill Yellow-legged Frog PVA revealed that, even with no dam effects considered (e.g., slower growth and increased egg and tadpole mortality), populations occurring along a hypothetical 6.2 mi reach were four times more likely to go extinct within 30 years when using the starting average density of adult females in regulated rivers (2.9/mi) compared to the starting average density of adult females from unregulated rivers (20/mi) (Kupferberg et al. 2009c). When the density of females in sparse populations was used (1.3/mi), the 30-year risk of extinction increased 13-fold (Ibid.). With dam effects, a number of the risk factors above contribute to the additional probability of local extinction such as living near their lower thermal tolerance and reduced recruitment and survival from scouring and stranding flows, poor food quality, and increased predation and competition (Kupferberg 1997a; Hoffmann and Sgrò 2011; Kupferberg et al. 2011a,b; Kupferberg et al. 2012; Eriksson et al. 2014). These factors act synergistically, contributing in part to the small size, high divergence, and low genetic diversity exhibited by many Foothill Yellow-legged Frog populations located in highly regulated watersheds (Kupferberg et al. 2012, Peek 2018).

5.0 EXISTING MANAGEMENT

5.1 Land Ownership within the California Range

Using the Department's Foothill Yellow-legged Frog presumed historical range boundary (Figure 1) and the California Protected Areas Database (CPAD), a GIS dataset of lands that are owned in fee title and protected for open space purposes by over 1,000 public agencies or non-profit organizations, the total area of the species' range in California comprises 33,656,857 ac (CPAD 2019, CWHR 2019). Approximately 37% is owned by federal agencies, 80% of which (10,060,100 ac) is managed by the Forest Service (Figure 29). Department of Fish and Wildlife-managed lands, State Parks, and other State agency-managed lands constitute around 2.6% of the range. The remainder of the range includes <1% Tribal lands, 2.3% other conserved lands (e.g., local and regional parks), and 57% private and government-managed lands that are not protected for open space purposes. It is important to note that even if included in the CPAD, a property's management does not necessarily benefit Foothill Yellow-legged Frogs. For example, the primary focus of many parks is to provide various types of recreation, which as previously described can have significantly adverse impacts on the species, and most BLM and Forest Service land is managed for multiple uses (e.g., timber harvest, mining, grazing, recreation).

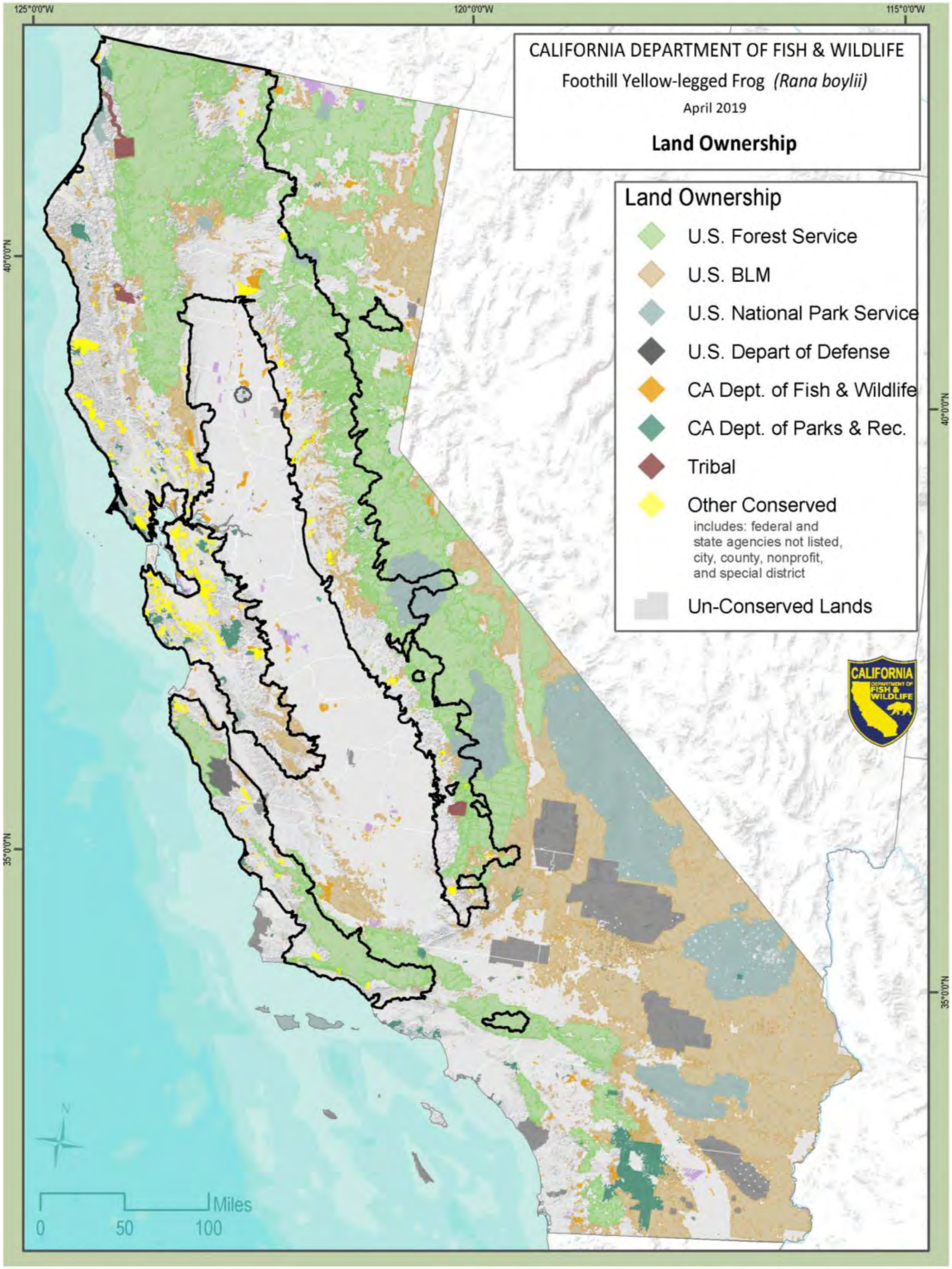


Figure 29. Conserved, Tribal, and other lands within the estimated historical range of Foothill Yellow-legged Frogs in California (BLM, CMD, CPAD, CWHR, DOD)

However, in some cases, changes in management to conserve the species may be easier to undertake on publicly-managed conserved lands than on private lands or public lands not classified as conserved.

5.2 Statewide Laws

The laws and regulations governing land use within the Foothill Yellow-legged Frog's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California that may provide some level of protection for Foothill Yellow-legged Frogs and their habitat. The following is not an exhaustive list.

5.2.1 National Environmental Policy Act and California Environmental Quality Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. As a BLM and Forest Service Sensitive Species, impacts to Foothill Yellow-legged Frogs are considered during NEPA analysis; however, the law has no requirement to minimize or mitigate adverse effects.

The California Environmental Quality Act (CEQA) is similar to NEPA; it requires state and local agencies to identify, analyze, and consider alternatives, and to publicly disclose environmental impacts from projects over which they have discretionary authority (Pub. Resources Code § 21000 et seq.). CEQA differs substantially from NEPA in requiring mitigation for significant adverse effects to a less than significant level unless overriding considerations are documented. CEQA requires an agency find that projects may have a significant effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380.). CEQA establishes a duty for public agencies to

avoid or minimize such significant effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to Foothill Yellow-legged Frogs, as an SSC, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA. However, a lead agency is not required to make a mandatory finding of significance conclusion for a project unless it determines on a project-specific basis that the species meets the CEQA criteria for rare, threatened, or endangered.

5.2.2 Clean Water Act and Porter-Cologne Water Quality Control Act

The Clean Water Act originated in 1948 as the Federal Water Pollution Control Act of 1948. It was heavily amended in 1972 and became known as the Clean Water Act (CWA). The purpose of the CWA was to establish regulations for the discharge of pollutants into waters of the United States and establish quality standards for surface waters. Section 404 of the CWA forbids the discharge of dredged or fill material into waters and wetlands without a permit from the ACOE. The CWA also requires an alternatives analysis, and the ACOE is directed to issue their permit for the least environmentally damaging practicable alternative. The definition of waters of the United States has changed substantially over time based on Supreme Court decisions and agency rule changes.

The Porter-Cologne Water Quality Act was established by the State in 1969 and is similar to the CWA in that it establishes water quality standards and regulates discharge of pollutants into state waters, but it also administers water rights, which regulate water diversions and extractions. The SWRCB and nine Regional Water Boards share responsibility for implementation and enforcement of Porter-Cologne as well as the CWA's National Pollutant Discharge Elimination System permitting.

5.2.3 Federal and California Wild and Scenic Rivers Acts

In 1968, the U.S. Congress passed the federal Wild and Scenic Rivers Act (WSRA) (16 U.S.C. § 1271, et seq.) which created the National Wild and Scenic River System. The WSRA requires the federal government to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The WSRA prohibits the federal government from building, licensing, funding or otherwise aiding in the building of dams or other project works on rivers or segments of designated rivers. The WSRA does not give the federal government control of private property including development along protected rivers.

California's Wild and Scenic Rivers Act was enacted in 1972 so rivers that "possess extraordinary scenic, recreational, fishery, or wildlife values shall be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the state." (Pub. Res. Code, § 5093.50). Designated waterways are codified in Public Resources Code sections 5093.50-5093.70. In 1981, most of California's designated Wild and Scenic Rivers were adopted into the federal system. Currently in California, 2,000 mi of 23 rivers are protected by the WSRA, most of which are located in the northwest. Foothill Yellow-legged Frogs have been observed in 11 of the 17 designated rivers within their range (CNDDB 2019).

5.2.4 Lake and Streambed Alteration Agreements

Fish and Game Code Section 1602 requires entities to notify the Department of activities that "divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake." If the activity may substantially adversely affect an existing fish and wildlife resource, the Department may enter into a lake or streambed alteration agreement with the entity that includes reasonable measures necessary to protect the fish or wildlife resource (Fish & G. Code, §1602, subd. (a)(4)(B)). A lake or stream alteration agreement does not authorize take of species listed as candidates, threatened, or endangered under CESA (see Protection Afforded by Listing for CESA compliance requirements).

5.2.5 Medicinal and Adult-Use Cannabis Regulation and Safety Act

The commercial cannabis cultivation industry is unique in that any entity applying for an annual cannabis cultivation license from California Department of Food and Agriculture (CDFA) must include "a copy of any final lake or streambed alteration agreement…or written verification from the California Department of Fish and Wildlife that a lake or streambed alteration agreement is not required" with their license application (Cal. Code Regs., tit. 3, § 8102, subd. (v)). The SWRCB also enforces the laws related to waste discharge and water diversions associated with cannabis cultivation (Cal. Code Regs., tit. 3, § 8102, subd. (p)).

5.2.6 Forest Practice Act

The Forest Practice Act was originally enacted in 1973 to ensure that logging in California is undertaken in a manner that will also preserve and protect the State's fish, wildlife, forests, and streams. This law and the regulations adopted by the California Board of Forestry and Fire Protection pursuant to it are collectively referred to as the Forest Practice Rules. The Forest Practice Rules implement the provisions of the Forest Practice Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. The California Department of Forestry and Fire Protection enforces these laws and regulations governing logging on private land.

5.2.7 Federal Power Act

The Federal Power Act and its major amendments are implemented and enforced by FERC and require licenses for dams operated to generate hydropower. One of the major amendments of the Federal Power Act required that these licenses "shall include conditions for the protection, mitigation and enhancement of fish and wildlife including related spawning grounds and habitat" (ECPA 1986). Hydropower licenses granted by FERC are usually valid for 30-50 years. If a licensee wants to renew their license, it must file a Notice of Intent and a pre-application document five years before the license expires to provide time for public scoping, any potentially new studies necessary to analyze project impacts and alternatives, and preparation of environmental documents. The applicant must officially apply for the new license at least two years before the current license expires.

As a federal agency, FERC must comply with federal environmental laws prior to issuing a new license or relicensing an existing hydropower project, which includes NEPA and ESA. As a result of environmental compliance or settlement agreements formed during the relicensing process, some operations have been modified and habitat restored to protect fish and wildlife. For example, the Lewiston Dam relicensing resulted in establishment of the Trinity River Restoration Program, which takes an ecosystem-approach to studying dam effects and protecting and restoring fish and wildlife populations downstream of the dam (Snover and Adams 2016). Similarly, relicensing of the Rock Creek-Cresta Project on the North Fork Feather River resulted in establishment of a multi-stakeholder Ecological Resources Committee (ERC). As a result of the ERC's studies and recommendations, pulse flows for whitewater boating were suspended for several years following declines of Foothill Yellow-legged Frogs, and the ERC is currently working toward augmenting the population in an attempt to increase abundance to a viable level.

5.3 Administrative and Regional Plans

5.3.1 Forest Plans

NORTHWEST FOREST PLAN

In 1994, BLM and the Forest Service adopted the Northwest Forest Plan to guide the management of over 37,500 mi^2 of federal lands in portions of northwestern California, Oregon, and Washington. The Northwest Forest Plan created an extensive network of forest reserves including Riparian Reserves. Riparian Reserves apply to all land designations to protect riparian dependent resources. With the exception of silvicultural activities consistent with Aquatic Conservation Strategy objectives, timber harvest is not permitted within Riparian Reserves, which can vary in width from 100 to 300 ft on either side of streams, depending on the classification of the stream or waterbody (USDA FS and BLM 1994). Fuel treatment and fire suppression strategies and practices implemented within these areas are designed to minimize disturbance.

SIERRA NEVADA FOREST PLAN

Land and Resource Management Plans for forests in the Sierra Nevada were changed in 2001 by the Sierra Nevada Forest Plan Amendment and subsequently adjusted through a supplemental Environmental Impact Statement and Record of Decision in 2004, referred to as the Sierra Nevada Framework (USDA FS 2004). This established an Aquatic Management Strategy with goals including maintenance and restoration of habitat to support viable populations of riparian-dependent species; spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction; instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats; the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity; and prevention of new introductions of invasive species and reduction of invasive species impacts that adversely affect the viability of native species. The Sierra Nevada Framework also includes Riparian Conservation Objectives and associated standards and guidelines specific to aquatic-dependent species, including the Foothill Yellow-legged Frog.

5.3.2 Resource Management Plans

Sequoia, Kings Canyon, and Yosemite National Parks fall within the historical range of the Foothill Yellow-legged Frog, but the species has been extirpated from these areas. The guiding principles for managing biological resources on National Park Service lands include maintenance of animal populations native to park ecosystems (Hayes et al. 2016). They also commit the agency to work with other land managers on regional scientific and planning efforts and maintenance or reintroduction of native species to the parks including conserving Foothill Yellow-legged Frogs in the Sierra Nevada (USDI NPS 1999 as cited in Hayes et al. 2016). A Sequoia and Kings Canyon National Parks Resource Management Plan does not include specific management goals for Foothill Yellow-legged Frogs, but it does include a discussion of the factors leading to the species' decline and measures to restore the integrity of aquatic ecosystems (Ibid.). The Yosemite National Park Resource Management Plan includes a goal of restoring

Foothill Yellow-legged Frogs to the Upper Tuolumne River below Hetch Hetchy Reservoir (USDI NPS 2003 as cited in Hayes et al. 2016).

5.3.3 FERC Licenses

Dozens of hydropower dams have been relicensed in California since 1999, and several are in the process of relicensing (FERC 2019). In addition to following the Federal Power Act and other applicable federal laws, Porter-Cologne Water Quality Act requires non-federal dam operators to obtain a Water Quality Certification (WQC) from the SWRCB. Before it can issue the WQC, the SWRCB must consult with the Department regarding the needs of fish and wildlife. Consequently, SWRCB includes conditions in the WQC that seek to minimize adverse effects to native species, and Foothill Yellow-legged Frogs have received some special considerations due to their sensitivity to dam operations during these licensing processes. As discussed above, the typical outcome is formation of an ERC-type group to implement the environmental compliance requirements and recommend changes to flow management to reduce impacts. The degree to which these considerations and modifications to dam operations results in its desired effect to protect healthy Foothill Yellow-legged Frog populations varies by site, but the myriad impacts from dams are difficult to overcome, and genetic evidence suggests populations in these highly regulated watersheds are fragmented and losing diversity (Peek 2018, S. Kupferberg pers. comm. 2019).

Foothill Yellow-legged Frog-specific requirements in license agreements fall into three general categories: data collection, modified flow regimes, and standard best management practices. Brief examples of each are described.

DATA COLLECTION

When little is known about the impacts of different flows and temperatures on Foothill Yellow-legged Frog occupancy and breeding success, data are collected and analyzed to inform recommendations for future modifications to operations such as temperature trigger thresholds. These surveys include locating egg masses and tadpoles, monitoring temperatures and flows, and recording their fate (e.g., successful development and metamorphosis, displacement, desiccation) during different flow operations and different water years. Examples of licenses with these conditions include the Lassen Lodge Project (FERC 2018), Rock Creek-Cresta Project (FERC 2009a), and El Dorado Project (EID 2007).

MODIFIED FLOW REGIMES

When enough data exist to understand the effect of different operations on Foothill Yellow-legged Frog occupancy and success, license conditions may include required minimum seasonal instream flows, specific thermal regimes, gradual ramping rates to reduce the likelihood of early life stage scour or stranding, freshet releases (winter/spring flooding simulation) to maintain riparian processes, and cancellation or prohibition of recreational pulse flows during the breeding season. Examples of licenses with these conditions include the Poe Hydroelectric Project (SWRCB 2017), Upper American Project (FERC 2014), and Pit 3, 4, 5 Project (FERC 2007b).

BEST MANAGEMENT PRACTICES

Efforts to reduce the impacts from maintenance activities and indirect operations include selective herbicide and pesticide application, aquatic invasive species monitoring and control, erosion control, and riparian buffers. Examples of licenses with these conditions include the South Feather Project (SWRCB 2018), Spring Gap-Stanislaus Project (FERC 2009b), and the Chili Bar Hydroelectric Project on the South Fork American River (FERC 2007a).

5.3.4 Habitat Conservation Plans and Natural Community Conservation Plans

Non-federal entities can obtain authorization for take of federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of a Habitat Conservation Plan (HCP) pursuant to Section 10 of the ESA. The take authorization can extend to species not currently listed under the ESA but which may become listed as threatened or endangered over the term of the HCP, which is often 25-75 years. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. A Natural Community Conservation Plan (NCCP) identifies and provides for the protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs that include Foothill Yellow-legged Frogs as a covered species, two of which are also NCCPs.

HUMBOLDT REDWOOD (FORMERLY PACIFIC LUMBER) COMPANY

The Humboldt Redwood Company (HRC) HCP covers 211,700 ac of private Coast Redwood and Douglas-fir forest in Humboldt County (HRC 2015). It is a 50-year HCP/incidental take permit (ITP) that was executed in 1999, revised in 2015 as part of its adaptive management strategy, and expires on March 1, 2049. The HCP includes an Amphibian and Reptile Conservation Plan and an Aquatics Conservation Plan with measures designed to sustain viable populations of Foothill Yellow-legged Frogs and other covered aquatic herpetofauna. These conservation measures include prohibiting or limiting tree harvest within Riparian Management Zones (RMZ), controlling sediment by maintaining roads and hillsides, restricting controlled burns to spring and fall in areas outside of the RMZ, conducting effectiveness monitoring throughout the life of the HCP, and use the data collected to adapt monitoring and management plans accordingly.

Watershed assessment surveys include observations of Foothill Yellow-legged Frogs and have documented their widespread distribution on HRC lands with a pattern of fewer near the coast in the fog belt and more inland (S. Chinnici pers. comm. 2017). The watersheds within the property are largely unaffected by dam-altered flow regimes or non-native species, so aside from the operations described under Timber Harvest above that are minimized to the extent feasible, the focus on suitable temperatures and denser canopy cover for salmonids may reduce habitat suitability for Foothill Yellow-legged Frogs over time (Ibid.).

San Joaquin County Multi-Species Habitat Conservation and Open Space Plan

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) is a 50-year HCP/ITP that was signed by the USFWS on November 14, 2000 (San Joaquin County 2000). The SJMSCP covers almost all of San Joaquin County except federal lands, a few select projects, and some properties with certain land uses, roughly 900,000 ac. At the time of execution, approximately 172 ac of habitat within the SJMSCP area in the southwest portion of the county were considered occupied by Foothill Yellow-legged Frogs with another 4,484 ac classified as potential habitat, but it appears the species had been considered extirpated before then (Jennings and Hayes 1994, San Joaquin County 2000, Lind 2005). The HCP estimates around 8% of the combined modeled habitat would be converted to other uses over the permit term, but the establishment of riparian preserves with buffers around Corral Hollow Creek, where the species occurred historically, was expected to offset those impacts (San Joaquin County 2000, SJCOG 2018). However, the HCP did not require surveys to determine if Foothill Yellow-legged Frogs are benefiting from its conservation measures (M. Grefsrud pers. comm. 2019).

East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan

The East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan (ECCC HCP/NCCP) is a multi-jurisdictional 30-year plan adopted in 2007 that covers over 174,018 ac in eastern Contra Costa County (Jones & Stokes 2006). The Foothill Yellow-legged Frog appears to be extirpated from the ECCC HCP/NCCP area (CNDDB 2019). Nevertheless, suitable habitat was mapped, and impacts were estimated at well under 1% of both breeding and migratory habitat (Jones & Stokes 2006). One of the HCP/NCCP's objectives is acquiring high-quality Foothill Yellow-legged Frog habitat that has been identified along Marsh Creek (Ibid.). In 2017, the Viera North Peak 160 ac property was acquired that possesses suitable habitat for Foothill Yellow-legged Frogs (ECCCHC 2018).

Santa Clara Valley Habitat Plan

The Santa Clara Valley Habitat Plan (SCVHP) is a 50-year HCP/NCCP covering over 519,506 ac in Santa Clara County (ICF 2012). As previously mentioned, Foothill Yellow-legged Frogs appear to have been extirpated from lower elevation sites, particularly below reservoirs in this area. Approximately 17% of modeled Foothill Yellow-legged Frog habitat, measured linearly along streams, was already permanently preserved, and the SCVHP seeks to increase that to 32%. The maximum allowable habitat loss is 7 mi permanent loss and 2 mi temporary loss, while 104 mi of modeled habitat is slated for protection. By mid-2018, 8% of impact area had been accrued and 3% of habitat protected (SCVHA 2019).

Green Diamond Aquatic Habitat Conservation Plan

Green Diamond Resources Company has an Aquatic Habitat Conservation Plan (AHCP) covering 400,000 ac of their land that is focused on cold water adapted species, but many of the conservation measures are expected to benefit Foothill Yellow-legged Frogs as well (K. Hamm pers. comm. 2017). Examples include slope stability and road management measures to reduce stream sedimentation from erosion and landslides, and limiting water drafting during low flow periods with screens over the pumps to avoid entraining animals (Ibid.). Although creating more open canopy areas and warmer water temperatures is not the goal of the AHCP, the areas that are suitable for Foothill Yellow-legged Frog breeding are likely to remain that way because they are wide channels that receive sufficient sunlight (Ibid.).

6.0 SUMMARY OF LISTING FACTORS

CESA's implementing regulations identify key factors relevant to the Department's analyses and the Fish and Game Commission's decision on whether to list a species as threatened or endangered. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

6.1 Present or Threatened Modification or Destruction of Habitat

Most of the factors affecting the Foothill Yellow-legged Frog's ability to survive and reproduce discussed above involve habitat destruction or degradation. The most widespread, and potentially most significant, threats are associated with dams and their flow regimes, particularly in areas where they are concentrated and occur in a series along a river. Dams and the way they are operated can have up- and downstream impacts to Foothill Yellow-legged Frogs. They can result in aseasonal or asynchronous breeding cues, scouring and stranding of egg masses and tadpoles, reduction in quality and quantity of breeding and rearing habitat, slower tadpole growth rate, barriers to gene flow among populations, and establishment and spread of non-native species (Hayes et al. 2016). These impacts appear to be most severe when the dam is operated for the generation of hydropower that use hydropeaking and pulse flows (Kupferberg et al. 2009c, Peek 2018). Foothill Yellow-legged Frog abundance below dams is an average of five times lower than in unregulated rivers (Kupferberg et al. 2012). The number, height, and distance upstream of dams in a watershed influenced whether Foothill Yellow-legged Frogs still occurred at sites that were occupied in 1975 (Ibid.). Water diversions for agricultural, industrial, and municipal uses also reduce the availability and quality of Foothill Yellow-legged Frog habitat. Dams are concentrated in the Bay Area, Sierra Nevada, and southern California (Figure 19), while hydropower plants are densest in the northern and central Sierra Nevada (Figure 21).

With predicted increases in the human population, ambitious renewable energy targets, higher temperatures, and more extreme and variable precipitation falling increasingly as rain rather than snow, the need for more and taller dams and water diversions for hydropower generation, flood control, and water storage and delivery is not expected to abate in the future. California voters approved Proposition 1, the Water Quality, Supply and Infrastructure Improvement Act of 2014, which dedicated $2.7 billion to water storage projects (PPIC 2018). In 2018, the California Water Commission approved funding for four new dams in California: expansion of Pacheco Reservoir (Santa Clara County), expansion of Los

Vaqueros Reservoir (Contra Costa County), Temperance Flat Dam (new construction) on the San Joaquin River (Fresno County), and the off-stream Sites Reservoir (new construction) diverting the Sacramento River (Colusa County) (CWC 2019). No historical records of Foothill Yellow-legged Frogs from the Los Vaqueros or Sites Reservoir areas exist in the CNDDB, and one historical (1950) collection is documented from the Pacheco Reservoir area (CNDDB 2019). However, the proposed Temperance Flat Dam site is downstream of one of the only known extant populations of Foothill Yellow-legged Frogs in the East/Southern Sierra clade (Ibid.).

The other widespread threat to Foothill Yellow-legged Frog habitat is climate change. While drought, wildland fires, floods, and landslides are natural, and ostensibly necessary, disturbance events for preservation of native biodiversity, climate change is expected to result in increased frequency and severity of these events in ways that may exceed species' abilities to adapt (Williams et al. 2008, Hoffmann and Sgrò 2011, Keely and Syphard 2016). These disturbance events, which can lead to local extirpations, will occur across a landscape of mostly fragmented and small populations, so the likelihood of natural recolonization will be highly impaired (S. Kupferberg pers. comm. 2019). Climatic changes in flow regime can lead to increased competition, predation, and disease transmission as species become concentrated in areas that remain wet into the late summer (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Loss of riparian vegetation from wildland fires can result in increased stream temperatures or concentrations of nutrients and trace heavy metals that inhibit growth and survival (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Stream sedimentation from landslides following fire or excessive precipitation can destroy or degrade breeding and rearing habitat (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). At least some models predict unprecedented dryness in the latter half of the century (Cook et al. 2015). The effects of climate change will be realized across the Foothill Yellow-legged Frog's range, and the severity of these effects will likely differ in ways that are difficult to predict. However, the impacts from extended droughts will likely be greatest in the areas that are naturally more arid, the lower elevations and latitudes of southern California and the foothills surrounding the Central Valley (Figure 25), although some models suggest the stress to vegetation communities may be relatively high in the North Coast (Figure 28).

While most future urbanization is predicted to occur in areas outside of the Foothill Yellow-legged Frog's range, it has already contributed to the loss and fragmentation of Foothill Yellow-legged Frog habitat in California. In addition, the increased predation, wildland fires, introduced species, road mortality, disease transmission, air and water pollution, and disturbance from recreation that can accompany urbanization expand its impact far beyond its physical footprint (Davidson et al. 2002, Syphard et al. 2007, Cook et al. 2012, Bar-Massada et al. 2014). Within the Foothill Yellow-legged Frog's historical range, these effects appear most significant and extensive in terms of population extirpations in southern California and the San Francisco Bay Area.

Several other activities have the potential to destroy or degrade Foothill Yellow-legged Frog habitat, but they are less common across the range. They also tend to have relatively small areas of impact, although they can be significant in those areas, particularly if populations are already small and declining. These include impacts from mining, cannabis cultivation, vineyard expansion, overgrazing, timber harvest, recreation, and some stream habitat restoration projects (Harvey and Lisle 1998, Belsky et al. 1999, Merelender 2000, Pilliod et al. 2003, Bauer et al. 2015, Kupferberg and Furey 2015).

6.2 Overexploitation

Foothill Yellow-legged Frogs are not threatened by overexploitation. There is no known pet trade for Foothill Yellow-legged Frogs (Lind 2005). During the massive frog harvest that accompanied the Gold Rush, some Foothill Yellow-legged Frogs were collected, but because they are relatively small and have irritating skin secretions, there was much less of a market for them (Jennings and Hayes 1985). Within these secretions is a peptide with antimicrobial activity that is particularly potent against *Candida albicans*, a human pathogen that has been developing resistance to traditional antifungal agents (Conlon et al. 2003). However, the peptide's therapeutic potential is limited by its strong hemolytic activity (destroys red blood cells), so further studies will focus on synthesizing analogs that can be used as antifungals, and collection of significant numbers of Foothill Yellow-legged Frogs for lab cultures is not expected (Ibid.).

Like all native California amphibians, collection of Foothill Yellow-legged Frogs is unlawful without a permit from the Department. They may only be collected for scientific, educational, or propagation reasons through a Scientific Collecting Permit (Fish & G. Code § 1002 et seq.). The Department has the discretion to limit or condition the number of individuals collected or handled to ensure no significant adverse effects. Incidental harm from authorized activities on other aquatic species can be avoided or minimized by the inclusion of special terms and conditions in permits.

6.3 Predation

Predation is a likely contributor to Foothill Yellow-legged Frog population declines where the habitat is degraded by one or many other risk factors (Hayes and Jennings 1986). Predation by native gartersnakes can be locally substantial; however, it may only have an appreciable population-level impact if the availability of escape refugia is diminished. For example, when streams dry and only pools remain, Foothill Yellow-legged Frogs are more vulnerable to predation by native and non-native species because they are concentrated in a small area, often with little aquatic cover.

Several studies have demonstrated the synergistic impacts of predators and other stressors. Foothill Yellow-legged Frogs, primarily as demonstrated through studies on tadpoles, are more susceptible to predation when exposed to some agrochemicals, cold water, high velocities, excess sedimentation, and even the presence of other species of predators (Harvey and Lisle 1998, Adams et al. 2003, Olson and Davis 2009, Kupferberg et al. 2011b, Kerby and Sih 2015, Catenazzi and Kupferberg 2018). Foothill Yellow-legged Frog tadpoles appear to be naïve to chemical cues from some non-native predators; they have not evolved those species-specific predator avoidance behaviors (Paoletti et al. 2011). Furthermore, early life stages are often more sensitive to environmental stressors, making them more vulnerable to predation, and Foothill Yellow-legged Frog population dynamics are highly sensitive to egg and tadpole mortality (Kats and Ferrer 2003, Kupferberg et al. 2009c). Predation pressure is likely positively associated with proximity to anthropogenic changes in the environment, so in more remote or pristine places, it probably does not have a serious population-level impact.

6.4 Competition

Intra- and interspecific competition in Foothill Yellow-legged Frogs has been documented. Intraspecific male-to-male competition for females has been reported (Rombough and Hayes 2007, Wilcox and Alvarez 2019). Observations include physical aggression and a non-random mating pattern in which larger males were more often engaged in breeding (Rombough and Hayes 2007, Wheeler and Welsh 2008). A behavior resembling clutch-piracy, where a satellite male attempts to fertilize already laid eggs, has also been documented (Rombough and Hayes 2007). These acts of competition play a role in population genetics, but they likely do not result in serious physical injury or mortality. Intraspecific competition among Foothill Yellow-legged Frog tadpoles was negligible (Kupferberg 1997a).

Interspecific competition appears to have a greater possibility of resulting in adverse impacts. Kupferberg (1997a) did not observe a significant change in tadpole mortality for Foothill Yellow-legged Frogs raised with Pacific Treefrogs compared to single-species controls. However, when reared together, Foothill Yellow-legged Frog tadpoles lost mass, while Pacific Treefrog tadpoles increased mass (Kerby and Sih 2015). As described previously under Introduced Species, Foothill Yellow-legged Frog tadpoles experienced significantly higher mortality and smaller size at metamorphosis when raised with bullfrog tadpoles (Kupferberg 1997a). The mechanism of these declines appeared to be exploitative competition (as opposed to interference) through the reduction of available algal resources from bullfrog tadpole grazing in the shared enclosures (Ibid.).

The degree to which competition threatens Foothill Yellow-legged Frogs likely depends on the number and density of non-native species in the area rather than intraspecific competition, and co-occurrence of Foothill Yellow-legged Frog and bullfrog tadpoles may be somewhat rare since the latter tends to breed in lentic (still water) environments (M. van Hattem pers. comm. 2019). Interspecific competition with other native species may have some minor adverse consequences on fitness.

6.5 Disease

Currently, the only disease known to pose a serious risk to Foothill Yellow-legged Frogs is Bd. Until 2017, the only published studies on the impact of Bd on Foothill Yellow-legged Frogs suggested it could reduce growth and body condition but was not lethal (Davidson et al. 2007, Lowe 2009, Adams et al. 2017b). However, two recent mass mortality events caused by chytridiomycosis proved they are susceptible to lethal effects, at least under certain conditions like drought-related concentration and presence of bullfrogs (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Some evidence indicates disease may have played a principal role in the disappearance of the species from southern California (Adams et al. 2017b). Bd is likely present in the environment throughout the Foothill Yellow-legged Frog's range, and with bullfrogs and treefrogs acting as carriers, it will remain a threat to the species; however, given the dynamics of the two recent die-offs in the San Francisco Bay area, the probability of future outbreaks may be greater in areas where the species is under additional stressors like drought and introduced species (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Therefore, as with predation, Foothill Yellow-legged Frogs are less likely to experience the adverse impacts of diseases in more remote areas with fewer anthropogenic changes to the environment.

6.6 Other Natural Events or Human-Related Activities

Agrochemicals, particularly organophosphates that act as endocrine disruptors, can travel substantial distances from the area of application through atmospheric drift and have been implicated in the disappearance and declines of many species of amphibians in California including Foothill Yellow-legged Frogs (LeNoir et al. 1999, Davidson 2004, Lind 2005, Olson and Davis 2009). Foothill Yellow-legged Frogs appear to be significantly more sensitive to the adverse impacts of some pesticides than other native species (Sparling and Fellers 2009, Kerby and Sih 2015). These include smaller body size, slower development rate, increased time to metamorphosis, diminished immune response, and greater vulnerability to predation and malformations (Kiesecker 2002, Hayes et al. 2006, Sparling and Fellers 2009, Kerby and Sih 2015). Some of the most dramatic declines experienced by ranids in California occurred in the Sierra Nevada east of the San Joaquin Valley, where over half of the state's total pesticide usage occurs (Sparling et al. 2001).

Many Foothill Yellow-legged Frog populations are small, isolated from other populations, and possess low genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). Genetic diversity is important in providing a population the capacity to evolve in response to environmental changes, and connectivity among populations is important for gene exchange and in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). Small populations are at much greater risk of extirpation primarily through the disproportionate impact of demographic, environmental, and genetic stochasticity than robust populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). Based on a Foothill Yellow-legged Frog PVA, populations in regulated rivers face a 4- to 13-fold greater extinction risk in 30 years than populations in unregulated rivers due to smaller population sizes (Kupferberg et al. 2009c). The threat posed by small population sizes is significant and the general pattern shows increases in severity from north to south; however, many sites, primarily in the northern Sierra Nevada, in watersheds with large hydropower projects are also at high risk.

7.0 PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). The conservation, protection, and enhancement of listed species and their habitat is of statewide concern (Fish & G. Code, § 2051(c)). "Take" is defined for CESA purposes as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86). The Fish and Game Code provides the Department with related authority to authorize "take" of species listed as threatened or endangered under certain circumstances (see, e.g., Fish & G. Code, §§ 2081, 2081.1, 2086, & 2835).

If the Foothill Yellow-legged Frog is listed under CESA, impacts of take caused by activities authorized through ITPs must be minimized and fully mitigated according to state standards (Fish & G. Code, § 2081, subd. (b)). These standards typically include protection of land in perpetuity with an easement, development and implementation of a species-specific adaptive management plan, and funding through an endowment to pay for long-term monitoring and maintenance to ensure the mitigation land meets performance criteria. Obtaining an ITP is voluntary. The Department cannot force compliance; however, any person violating the take prohibition may be criminally and civilly liable under state law.

Additional protection of Foothill Yellow-legged Frogs following listing would be expected to occur through state and local agency environmental review under CEQA. CEQA requires affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on rare, threatened, and endangered species. In common practice, potential impacts to listed species are examined more closely in CEQA documents than potential impacts to unlisted species. Where significant impacts are identified under CEQA, the Department expects project-specific avoidance, minimization, and mitigation measures to benefit the species. State listing, in this respect, and consultation with the Department during state and local agency environmental review under CEQA would be expected to benefit the Foothill Yellow-legged Frog in terms of reducing impacts from individual projects, which might otherwise occur absent listing.

For some species, CESA listing may prompt increased interagency coordination, particularly between the National Marine Fisheries Service and the Department, and the likelihood that state and federal land and resource management agencies will allocate funds toward protection and recovery actions. In the case of the Foothill Yellow-legged Frog, some multi-agency efforts exist, often associated with FERC license requirements, to improve habitat conditions and augment declining populations. The USFWS is leading an effort to develop range-wide and regional Foothill Yellow-legged Frog conservation strategies, and CESA listing may result in increased priority for limited conservation funds such as State Wildlife Grants and funding opportunities connected to level of imperilment on the International Union for Conservation of Nature's Red List.

8.0 LISTING RECOMMENDATION

CESA directs the Department to prepare this report regarding the status of the Foothill Yellow-legged Frog in California based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067).

The Legislature left to the Department and the Commission, which are responsible for providing the best scientific information and for making listing decisions, respectively, the interpretation of what constitutes a "species or subspecies" under CESA. (*Cal. Forestry Assn. v. Cal. Fish and G. Com.* (2007) 156

Cal.App.4th 1535, 1548-49). Courts should give a “great deal of deference” to Commission listing determinations supported by Department scientific expertise (*Central Coast Forest Assn. v. Fish & G. Com.* (2018) 18 Cal. App. 5th 1191, 1198-99). The Commission’s authority to list necessarily includes discretion to determine what constitutes a species or subspecies (*Id*. at p. 1237). The Commission’s determination of which populations to list under CESA goes beyond genetics to questions of policy (*Ibid*.).

As described above, genetic divergence among populations and genetic diversity within those populations are critical to species protection. Genetic divergence indicates the amount of time that population lineages have been separated. Effective conservation strategies often identify the most divergent clades in a group of lineages as key management units. While it can be difficult to determine when populations within species have sufficiently differentiated to be considered separate species or subspecies, the population-genetics approach using the fixation index F_{ST} is the most widely used summary measure of population divergence. The high divergence values calculated for F_{ST} for Foothill Yellow-legged Frog suggest a long history of reproductive isolation for the six clades described. Further, genetic diversity provides information on population health and indicates the extent to which populations have the capacity to adapt to changing condition. Amphibians may be particularly vulnerable to the effects of low genetic diversity. The levels of genetic diversity within the six Foothill Yellow-legged Frog clades differed significantly, largely following a north-to-south pattern, and the significant reductions in connectivity and genetic diversity over short evolutionary periods raises concerns with respect to population viability and persistence.

A population of organisms considered distinct for conservation purposes based on scientific analysis of the reproductive isolation and genetic differences between population groups is eligible for listing under CESA (see *Cal. Forestry Assn. v. Cal. Fish and G.*, supra, 156 Cal.App.4th 1535 [upholding the Commission’s listing of two evolutionarily significant units of Coho Salmon]. The Department has recognized that similar populations of a species can be grouped for efficient protection of bio- and genetic diversity (*Id*. at p. 1546-47). Further, genetic structure and biodiversity in California populations are important because they foster enhanced long-term stability (*Id*. at p. 1547). Diversity spreads risk and supports redundancy in the case of catastrophes, provides a range of raw materials that allow adaptation and persistence in the face of long-term environmental change, and leads to greater abundance (*Ibid*.). In consideration of the scientific information contained herein, the Department has determined that each of the six Foothill Yellow-legged Frog genetic clades described in this status report— Northwest/North Coast, Feather River, Northeast/Northern Sierra, East/Southern Sierra, West/Central Coast, and Southwest/South Coast—qualify as a “species or subspecies” under CESA and listing the Foothill Yellow-legged Frog by genetic clade is the prudent approach due to the disparate degrees of imperilment among them. The Department, based on the best science, included areas where the historical range is uncertain, but populations may be discovered within the defined clade boundaries (Figure 6). The Department includes and makes the following recommendation in this status report as submitted to the Commission in an advisory capacity based on the best available science.

NORTHWEST/NORTH COAST: Not warranted at this time.

Clade-level Summary: This is the largest clade with the most robust populations (highest densities) and the greatest genetic diversity. This area is the least densely populated by humans; contains relatively few hydropower dams, particularly further north; and has the highest precipitation in the species' California range. The species is still known to occur in most, if not all, historically occupied watersheds; presumed extirpations are mainly concentrated in the southern portion of the clade around the heavily urbanized San Francisco Bay area. The proliferation of cannabis cultivation, particularly illicit grows in and around the Emerald Triangle, the apparent increase in severe wildland fires in the area, and potential climate change effects are cause for concern, so the species should remain a Priority 1 SSC here with continued monitoring for any change in its status.

FEATHER RIVER: Threatened.

Clade-level Summary: This is the smallest clade and has a high density of hydropower dams. It also recently experienced one of the largest, most catastrophic wildfires in California history. Despite these threats, Foothill Yellow-legged Frogs appear to continue to be relatively broadly distributed within the clade, although with all the dams in the area, most populations are likely disconnected. The area is more mesic and experienced less of a change in precipitation in the most recent drought than the clades south of it. The clade is remarkable genetically and morphologically as it is the only area where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs overlap and can hybridize. The genetic variation within the clade is greater than the other clades except for the Northwest/North Coast. Most of the area within the clade's boundaries is Forest Service-managed, and little urbanization pressure or known extirpations exist in this area. Recent FERC licenses in this area require Foothill Yellow-legged Frog specific conservation, which to date has included cancelling pulse flows, removing encroaching vegetation, and translocating egg masses and in situ head-starting to augment a population that had recently declined.

NORTHEAST/NORTHERN SIERRA: Threatened.

Clade-level Summary: The Northeast/Northern Sierra clade shares many of the same threats as the Feather River clade (e.g., relatively small area with many hydropower dams). The area is also more mesic and experienced less of a change in precipitation during the recent drought than more southern clades. However, this pattern may not continue as some models suggest loss of snowmelt will be greater in the northern Sierra Nevada, and one of the climate change exposure models suggests that a comparatively large proportion of the lower elevations will experience climatic conditions not currently known from the area (i.e., non-analog) by the end of the century. Recent surveys suggest the area continues to support several populations of the species, some of which seem to remain robust, with a fairly widespread distribution. However, genetic analyses from several watersheds suggest many of these populations are isolated and diverging, particularly in regulated reaches with hydropeaking flows.

EAST/SOUTHERN SIERRA: Endangered.

Clade-level Summary: Like the Southwest/South Coast clade, widespread extirpations in this area were observed as early as the 1970s. Dams and introduced species were credited as causal factors in these declines in distribution and abundance, and mining and disease may also have contributed. This area is relatively arid, and drought effects appear greater here than in northern areas that exhibit both more precipitation and a smaller difference between drought years and the historical average. There is a relatively high number of hydropower generating dams in series along the major rivers in this clade and at least one new proposed dam near one of the remaining populations. This area is also the most heavily impacted by agrochemicals from the San Joaquin Valley.

WEST/CENTRAL COAST: Endangered.

Clade-level Summary: Foothill Yellow-legged Frogs appear to be extirpated from a relatively large proportion of historically occupied sites within this clade, particularly in the heavily urbanized northern portion around the San Francisco Bay. In the northern portion of the clade, nearly all the remaining populations (which may be fewer than a dozen) are located above dams, which line the mountains surrounding the Bay Area, and two are known to have undergone recent disease-associated die-offs. These higher elevation sites are more often intermittent or ephemeral streams than the lower in the watersheds. As a result, the more frequent and extreme droughts that have dried up large areas may have contributed to recent declines. Illegal cannabis cultivation, historical mining effects, overgrazing, and recreation likely contributed to declines and may continue to threaten remaining populations.

SOUTHWEST/SOUTH COAST: Endangered.

Clade-level Summary: The most extensive extirpations have occurred in this clade, and only two known extant populations remain. Both are small with apparently low genetic diversity, making them especially vulnerable to extirpation. This is also an area with a large human population, many dams, and naturally arid, fire-prone environments, particularly in the southern portion of the clade. Introduced species are widespread, and cannabis cultivation is rivaling the Emerald Triangle in some areas (e.g., Santa Barbara County). Introduced species, expanded recreation, disease, and flooding appear to have contributed to the widespread extirpations in southern California over 40 years ago.

9.0 MANAGEMENT RECOMMENDATIONS

The Department has evaluated existing management recommendations and available literature applicable to the management and conservation of the Foothill Yellow-legged Frog to arrive at the following recommendations. These recommendations, which represent the best available scientific information, are largely derived from the Foothill Yellow-legged Frog Conservation Assessment, the California Energy Commission’s Public Interest Energy Research Reports, the Recovery Plans of West Coast Salmon and Steelhead, and the California Amphibian and Reptile Species of Special Concern (Kupferberg et al. 2009b,c, 2011a; NMFS 2012, 2013, 2014, 2016; Hayes et al. 2016; Thomson et al. 2016).

9.1 Conservation Strategies

Maintain current distribution and genetic diversity by protecting existing Foothill Yellow-legged Frog populations and their habitats and providing opportunities for increased connectivity and gene flow. Increase abundance to viable levels in populations at risk of extirpation due to small sizes, when appropriate, through in situ or ex situ captive propagation and translocations. Use habitat suitability and hydrodynamic habitat models to identify historically occupied sites that may currently support Foothill Yellow-legged Frogs or could with minor habitat improvements or modified management. Investigate the utility of using other amphibians as indicators of whether a site may be able to support Foothill Yellow-legged Frogs like the presence of Pacific Treefrogs or newts (*Taricha* spp.). Re-establish extirpated populations in suitable habitat through captive propagation and translocations. Prioritize areas in the southern portions of the species' range where extirpations and loss of diversity have been the most severe.

If establishing reserves, prioritize areas containing high genetic variation in Foothill Yellow-legged Frogs (and among various native species) and climatic gradients where selection varies over a small geographical area. Environmental heterogeneity can provide a means of maintaining phenotypic variability which increases the adaptive capacity of populations as conditions change. These reserves should provide connectivity to other occupied areas to facilitate gene flow and allow for ongoing selection to fire, drought, thermal stresses, and changing species interactions.

9.2 Research and Monitoring

Attempt to rediscover potentially remnant populations in areas where they are considered extirpated, prioritizing the southern portions of the species' range. Collect environmental DNA in addition to conducting visual encounter surveys to improve detectability. Concurrently assess presence of threats and habitat suitability to determine if future reintroductions may be possible. Collect genetic samples from any Foothill Yellow-legged Frogs captured for use in landscape genomics analyses and possible future captive propagation and translocation efforts. Attempt to better clarify clade boundaries where there is uncertainty. Study whether small populations are at risk of inbreeding depression, whether genetic rescue should be attempted, and if so, whether that results in hybrid vigor or outbreeding depression.

Continue to evaluate how water operations affect Foothill Yellow-legged Frog population demographics. Support and coordinate existing monitoring efforts and establish more long-term monitoring programs in regulated and unregulated (reference) rivers across the species' range, but particularly in areas like the Sierra Nevada where most large hydropower dams in the species' range are concentrated. Assess whether the timing of pulse flows influences population dynamics, particularly whether early releases have a disproportionately large adverse effect by eliminating the reproductive success of the largest, most fecund females, who appear to breed earlier in the season. Investigate survival rates in poorly understood life stages, such as tadpoles, young of the year, and juveniles. Determine the extent to which pulse flows contribute to displacement and mortality of post-metamorphic life stages.

Collect habitat variables that correlate with healthy populations to develop more site-specific habitat suitability and hydrodynamic models. Investigate the upstream and downstream extent of populations to document the conditions along the peripheries where marginal habitat becomes completely unsuitable. Study the potential synergistic effect of increased flow velocity and decreased temperature on tadpole fitness. Examine the relationship between changes in flow, breeding and rearing habitat connectivity, and scouring and stranding to develop site-specific, benign ramping rates. Incorporate these data and demographic data into future PVAs for use in establishing frog-friendly flow regimes in future FERC relicensing or license amendment efforts and habitat restoration projects. Ensure long-term funding for post-license restoration monitoring to evaluate attainment of expected results and for use in adapting management strategies accordingly.

Evaluate the distribution of other threats such as cannabis cultivation, vineyard expansion, livestock grazing, mining, timber harvest, and urbanization and roads in the Foothill Yellow-legged Frog's range. Study the short- and long-term effects of wildland fires and fire management strategies. Assess the extent to which these potential threats pose a risk to Foothill Yellow-legged Frog persistence in both regulated and unregulated systems.

Investigate how reach-level or short-distance habitat suitability and hydrodynamic models can be extrapolated to a watershed level. Study habitat connectivity needs such as the proximity of breeding sites and other suitable habitats along a waterway necessary to maintain gene flow and functioning meta-population dynamics.

9.3 Habitat Restoration and Watershed Management

Remove or modify physical barriers like dams and poorly constructed culverts and bridges to improve connectivity and natural stream processes. Remove anthropogenic features that support introduced predators and competitors such as abandoned mine tailing ponds that support bullfrog breeding. Where feasible, conduct active control and management efforts to decrease the abundance of bullfrogs, non-native fish, and crayfish (where they are non-native). In managed rivers, manipulate stream flows to negatively affect non-native species that are not adapted to a winter flood/summer drought flow regime. Where appropriate, construct natural barriers (e.g., boulders, waterfalls) to prevent upstream migration of crayfish and non-native fish.

Adopt a multi-species approach to channel restoration projects and managed flow regimes (thermal, velocity, timing) and mimic the natural hydrograph to the greatest extent possible. When this is impractical or infeasible, focus on minimizing adverse impacts by gradually ramping discharge up and down, creating and maintaining gently sloping and sun-lit gravel bars and warm calm edgewater habitats for tadpole rearing, and mixing hypolimnetic water (from the lower colder stratum in a reservoir) with warmer surface water before release if necessary to ensure appropriate thermal conditions for successful metamorphosis. Promote restoration and maintenance of habitat heterogeneity (different depths, velocities, substrates, etc.) and connectivity to support all life stages and gene flow. Avoid damaging Foothill Yellow-legged Frog breeding habitat when restoring habitat for other focal species like listed anadromous salmonids.

9.4 Regulatory Considerations and Best Management Practices

Develop range-wide minimum summer base flow requirements that protect Foothill Yellow-legged Frogs and their habitat with appropriate provisions to address regional differences using new more ecologically meaningful approaches such as percent-of-flow (or modified percent-of-flow) strategies for watersheds (e.g., Yarnell et al. 2013, Mierau et al. 2018). Limit water diversions during the dry season and construction of new in-stream dams by focusing on off-stream water storage strategies that are managed to prevent establishment of non-native predators and competitors.

Ensure and improve protection of riparian systems. Require maintenance of appropriate riparian buffers and canopy coverage (i.e., partly shaded) around occupied habitat or habitat that has been identified for potential future reintroductions. Restrict instream work to dry periods where possible. Prohibit fording in and around breeding habitat. Avoid working near streams after the first major rains in the fall when Foothill Yellow-legged Frogs may be moving upslope toward tributaries and overwintering sites. Use a 0.125 inch mesh screen on water diversion pumps and limit the rate and amount of water diverted such that depth and flow remain sufficient to support Foothill Yellow-legged Frogs of all life stages occupying the immediate area and downstream. Install exclusion fencing, where appropriate, being mindful that predators such as river otters may take advantage of the fencing to catch frogs (S. Kupferberg pers. comm. 2019). If Foothill Yellow-legged Frog relocation is required, conduct this activity early in the season because moving egg masses is easier than moving tadpoles.

Reduce habitat degradation from sedimentation, pesticides, herbicides, and other non-point source waste discharges from adjacent land uses, including along tributaries of rivers and streams. Limit mining to parts of rivers not used for oviposition, such as deeper pools or reaches with few tributaries, and at times of year when frogs are more common in tributaries (i.e., fall and winter). Manage recreational activities in or adjacent to Foothill Yellow-legged Frog habitat (e.g., OHV and hiking trails, camp sites, boating ingress/egress, flows, and speeds) in a way that minimizes adverse impacts. Siting cannabis grows in areas with better access to roads, gentler slopes, and ample water resources could significantly reduce threats to the environment. Determine which, when, and where agrochemicals should be restricted to reduce harm to Foothill Yellow-legged Frogs and other species. Ensure all new road crossings and modifications to existing crossings (bridges, culverts, fills, and other crossings) accommodate at least 100-year flood flows and associated bedload and debris.

9.5 Partnerships and Coordination

Establish collaborative partnerships with agencies, universities, and non-governmental organizations working on salmon and steelhead recovery and stream restoration. Anadromous salmonids share many of the same threats as Foothill Yellow-legged Frogs, and recovery actions such as barrier removal, restoration of natural sediment transport processes, reduction in pollution, and eradication of non-native predators should be planned and executed in a manner that benefits the frogs as well. Ensure Integrated Regional Water Management Plans and fisheries restoration programs take Foothill Yellow-legged Frog conservation into consideration during design, implementation, and maintenance.

Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems. Promote and implement initiatives and programs that improve water conservation use efficiency, reduce greenhouse gas emissions, promote sustainable agriculture and smart urban growth, and protect and restore riparian ecosystems. Shift reliance from on-stream storage to off-stream storage, resolve frost protection issues (water withdrawals), and ensure necessary flows for all life stages in all water years.

Establish a Department-coordinated staff and citizen scientist program to systematically monitor occupied stream reaches across the species' range.

9.6 Education and Enforcement

Support programs to provide educational outreach and local involvement in restoration and watershed stewardship, such as Project Wild, Adopt a Watershed, school district environmental camps, and other programs teaching the effects of human land and water use on Foothill Yellow-legged Frog survival.

Provide additional funding for increased law enforcement to reduce ecologically harmful stream alterations and water pollution and to ensure adequate protection for Foothill Yellow-legged Frogs at pumps and diversions. Identify and address illegal water diverters and out-of-compliance diverters, seasons of diversion, off-stream reservoirs, well pumping, and bypass flows to protect Foothill Yellow-legged Frogs. Prosecute violators accordingly. Provide additional environmental and enforcement staff for oversight of permit and environmental document compliance (i.e., fulfilling commitments in NEPA and CEQA documents to undertake activities to avoid, minimize, and mitigate adverse impacts; carrying out mitigation requirements in HCPs, NCCPs, FERC licenses; etc.).

10.0 ECONOMIC CONSIDERATIONS

The Department is charged in an advisory capacity in the present context to provide a written report and a related recommendation to the Commission based on the best scientific information available regarding the status of Foothill Yellow-legged Frog in California. The Department is not required to prepare an analysis of economic impacts (See Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

REFERENCES

Literature Cited

Ackerly, D., A. Jones, M. Stacey, and B. Riordan. 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.

Adams, A.J., S.J. Kupferberg, M.Q. Wilber, A.P. Pessier, M. Grefsrud, S. Bobzien, V.T. Vredenburg, and C.J. Briggs. 2017a. Extreme Drought, Host Density, Sex, and Bullfrogs Influence Fungal Pathogen Infections in a Declining Lotic Amphibian. Ecosphere 8(3):e01740. DOI: 10.1002/ecs2.1740

Adams, A.J., A.P. Pessier, and C.J. Briggs. 2017b. Rapid Extirpation of a North American Frog Coincides with an Increase in Fungal Pathogen Prevalence: Historical Analysis and Implications for Reintroduction. Ecology and Evolution 7(23):10216-10232. DOI: 10.1002/ece3.3468

Adams, M.J., C.A. Pearl, and R.B. Bury. 2003. Indirect Facilitation of an Anuran Invasion by Non-native Fishes. Ecology Letters 6:343-351.

Allen, M., and S. Riley. 2012. Effects of Electrofishing on Adult Frogs. Unpublished report prepared by Normandeau Associates, Inc., Arcata, CA.

Allentoft, M.E., and J. O'Brien. 2010. Global Amphibian Declines, Loss of Genetic Diversity and Fitness: A Review. Diversity 2: 47-71. DOI:10.3390/d2010047

Alpers, C.N., M.P. Hunerlach, J.T. May, R.L. Hothem, H.E. Taylor, R.C. Antweiler, J.F. De Wild, and D.A. Lawler. 2005. Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999–2001: U.S. Geological Survey Scientific Investigations Report 2004-5251.

Alston, J.M., J.T. Lapsley, and O. Sambucci. 2018. Grape and Wine Production in California. Pp. 1-28 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/a1/1e/a11eb90f-af2a-4deb-ae58-9af60ce6aa40/grape_and_wine_production.pdf

American Bankers Association [ABA]. 2019. Marijuana and Banking. Website accessed on April 5, 2019 at https://www.aba.com/advocacy/issues/pages/marijuana-banking.aspx

AmphibiaWeb. 2019a. Phylogeny, Taxonomy, and Nomenclature – A Primer. University of California, Berkeley, CA. Website accessed on July 8, 2019 at https://amphibiaweb.org/taxonomy/index.html

AmphibiaWeb. 2019b. Ranidae. University of California, Berkeley, CA. Website accessed June 24, 2019 at https://amphibiaweb.org/lists/Ranidae.shtml

Ashton, D.T. 2002. A Comparison of Abundance and Assemblage of Lotic Amphibians in Late-Seral and Second-Growth Redwood Forests in Humboldt County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Ashton, D.T., J.B. Bettaso, and H.H. Welsh, Jr. 2010. Foothill Yellow-legged Frog (*Rana boylii*) Distribution and Phenology Relative to Flow Management on the Trinity River. Oral presentation provided at the Trinity River Restoration Program's 2010 Trinity River Science Symposium 13 January 2010. http://www.trrp.net/library/document/?id=410

Ashton, D.T., A.J. Lind, and K.E. Schlick. 1997. Foothill Yellow-Legged Frog (*Rana boylii*) Natural History. USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA.

Ashton, D.T., and R.J. Nakamoto. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 38(4):442.

Baird, S.F. 1854. Descriptions of New Genera and Species of North American Frogs. Proceedings of the Academy of Natural Sciences of Philadelphia 7:62.

Bar-Massada, A., V.C. Radeloff, and S.I. Stewart. 2014. Biotic and Abiotic Effects of Human Settlements in the Wildland–Urban Interface. BioScience 64(5):429-437.

Bauer S.D., J.L. Olson, A.C. Cockrill, M.G. van Hattem, L.M. Miller, M. Tauzer, and G. Leppig. 2015. Impacts of Surface Water Diversions for Marijuana-Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLoS ONE 10(3):e0120016. https://doi.org/10.1371/journal.pone.0120016

Bedwell, M.E. 2018. Using Genetic Tools to Investigate Distribution and Connectivity of Two Sierra Nevada Amphibians, *Rana sierrae* and *Rana boylii*. Master's Thesis. Washington State University, Pullman, WA.

Bee, M.A., and E.M. Swanson. 2007. Auditory Masking of Anuran Advertisement Calls by Road Traffic Noise. Animal Behaviour 74:1765-1776.

Beebee, T.J.C. 1995. Amphibian Breeding and Climate. Nature 374:219-220.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing in the Riparian Zone: Impact and Management Perspectives. Pp. 184-189 *In* R.D. Johnson and J.F. McCormick (Technical Coordinators). Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, U.S. Department of Agriculture, Forest Service, General Technical Report WO-12.

Belsky, A.J, A. Matzke, and S. Uselman. 1999. Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States. Journal of Soil and Water Conservation 54(1):419-431.

Blaustein, A.R., D.G. Hokit, R.K. O'Hara and R.A. Holt. 1994. Pathogenic Fungus Contributes to Amphibian Losses in the Pacific Northwest. Biological Conservation 67(3):251-254.

Bobzien, S., and J.E. DiDonato. 2007. The Status of the California Tiger Salamander (*Ambystoma californiense*), California Red-Legged Frog (*Rana draytonii*), Foothill Yellow-Legged Frog (*Rana boylii*), and Other Aquatic Herpetofauna in the East Bay Regional Park District, California. Unpublished report. East Bay Regional Park District, Oakland, CA.

Bogan, M.T., R.A. Leidy, L. Neuhaus, C.J. Hernandez, and S.M. Carlson. 2019. Biodiversity Value of Remnant Pools in an Intermittent Stream During the Great California Drought. Aquatic Conservation: Marine and Freshwater Ecosystems 29:976-989. https://doi.org/10.1002/aqc.3109

Bondi, C.A., S.M. Yarnell, and A.J. Lind. 2013. Transferability of Habitat Suitability Criteria for a Stream Breeding Frog (*Rana boylii*) in the Sierra Nevada, California. Herpetological Conservation and Biology 8(1):88-103.

Bourque, R.M. 2008. Spatial Ecology of an Inland Population of the Foothill Yellow-Legged Frog (*Rana boylii*) in Tehama County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Bourque, R.M., and J.B. Bettaso. 2011. *Rana boylii* (Foothill Yellow-legged Frogs). Reproduction. Herpetological Review 42(4):589.

Brattstrom, B.H. 1962. Thermal Control of Aggregation Behavior in Tadpoles. Herpetologica 18(1):38-46.

Breedveld, K.G.H., and M.J. Ellis. 2018. Foothill Yellow-legged Frog (*Rana boylii*) Growth, Longevity, and Population Dynamics from a 9-Year Photographic Capture-Recapture Study. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Brehme, C.S., S.A. Hathaway, and R.N. Fisher. 2018. An Objective Road Risk Assessment Method for Multiple Species: Ranking 166 Reptiles and Amphibians in California. Landscape Ecology 33:911-935. DOI: 10.1007/s10980-018-0640-1

Brode, J.M., and R.B. Bury. 1984. The Importance of Riparian Systems to Amphibians and Reptiles. Pp. 30-36 *In* R. E. Warner and K. M. Hendrix (Editors). Proceedings of the California Riparian Systems Conference, University of California, Davis.

Bursey, C.R., S.R. Goldberg, and J.B. Bettaso. 2010. Persistence and Stability of the Component Helminth Community of the Foothill Yellow-Legged Frog, *Rana boylii* (Ranidae), from Humboldt County, California, 1964–1965, Versus 2004–2007. The American Midland Naturalist 163(2):476-482. https://doi.org/10.1674/0003-0031-163.2.476

Burton, C.A., T.M. Hoefen, G.S. Plumlee, K.L. Baumberger, A.R. Backlin, E. Gallegos, and R.N. Fisher. 2016. Trace Elements in Stormflow, Ash, and Burned Soil Following the 2009 Station Fire in Southern California. PLoS ONE 11(5):e0153372. DOI: 10.1371/journal.pone.0153372

Bury, R.B. 1972. The Effects of Diesel Fuel on a Stream Fauna. California Department of Fish and Game Bulletin 58:291-295.

Bury, R.B., and N.R. Sisk. 1997. Amphibians and Reptiles of the Cow Creek Watershed in the BLM-Roseburg District. Draft report submitted to BLM-Roseburg District and Oregon Department of Fish and Wildlife-Roseburg. Biological Resources Division, USGS, Corvallis, OR.

Butsic, V., and J.C. Brenner. 2016. Cannabis (*Cannabis sativa* or *C. indica*) Agriculture and the Environment: A Systematic, Spacially-explicit Survey and Potential Impacts. Environmental Research Letters 11(4):044023.

California Department of Fish and Wildlife [CDFW]. 2018a. Considerations for Conserving the Foothill Yellow-Legged Frog. California Department of Fish and Wildlife; 5/14/2018. http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=157562

California Department of Fish and Wildlife [CDFW]. 2018b. Green Diamond Resource Company Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-026-01. Northern Region, Eureka, CA.

California Department of Fish and Wildlife [CDFW]. 2018c. Humboldt Redwood Company Foothill Yellow-legged Frog Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-039-01. Northern Region, Eureka, CA.

California Department of Food and Agriculture [CDFA]. 2018a. California Agricultural Statistics Review 2017-2018. https://www.cdfa.ca.gov/statistics/PDFs/2017-18AgReport.pdf

California Department of Food and Agriculture [CDFA]. 2018b. California Grape Acreage Report, 2017 Summary. https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Acreage/2018/201804grpacSUMMARY.pdf

California Department of Forestry and Fire Protection [CAL FIRE]. 2019. Top 20 Largest California Wildfires. http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf

California Department of Pesticide Regulation [CDPR]. 2018. The Top 100 Sites Used by Pounds of Active Ingredients Statewide in 2016 (All Pesticides Combined). https://www.cdpr.ca.gov/docs/pur/pur16rep/top_100_sites_lbs_2016.pdf

California Department of Water Resources [CDWR]. 2016. Drought and Water Year 2016: Hot and Dry Conditions Continue. 2016 California Drought Update.

California Natural Resources Agency [CNRA]. 2016. Safeguarding California: Implementation Action Plan. California Natural Resources Agency. http://resources.ca.gov/docs/climate/safeguarding/Safeguarding%20California-Implementation%20Action%20Plans.pdf

California Secretary of State [CSOS]. 2016. Proposition 64 Marijuana Legalization Initiative Statute, Analysis by the Legislative Analyst.

California Water Commission [CWC]. 2019. Proposition 1 Water Storage Investment Program: Funding the Public Benefits of Water Storage Projects. Website accessed April 5, 2019 at https://cwc.ca.gov/Water-Storage

Carah, J.K., J.K. Howard, S.E. Thompson, A.G. Short Gianotti, S.D. Bauer, S.M. Carlson, D.N. Dralle, M.W. Gabriel, L.L. Hulette, B.J. Johnson, C.A. Knight, S.J. Kupferberg, S.L. Martin, R.L. Naylor, and M.E. Power. 2015. High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization. BioScience 65(8):822-829. DOI: 10.1093/biosci/biv083

Case, M.J., J.J. Lawler, and J.A. Tomasevic. 2015. Relative Sensitivity to Climate Change of Species in Northwestern North America. Biological Conservation 187:127-133.

Catenazzi, A., and S.J. Kupferberg. 2013. The Importance of Thermal Conditions to Recruitment Success in Stream-Breeding Frog Populations Distributed Across a Productivity Gradient. Biological Conservation 168:40-48.

Catenazzi, A., and S.J. Kupferberg. 2017. Variation in Thermal Niche of a Declining River-breeding Frog: From Counter-Gradient Responses to Population Distribution Patterns. Freshwater Biology 62:1255-1265.

Catenazzi, A., and S.J. Kupferberg. 2018. Consequences of Dam-Altered Thermal Regimes for a Riverine Herbivore's Digestive Efficiency, Growth and Vulnerability to Predation. Freshwater Biology 63(9):1037-1048. DOI: 10.1111/fwb.13112

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent Changes Towards Earlier Springs: Early Signs of Climate Warming in Western North America? Watershed Management Council Networker (Spring):3-7.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate Change Scenarios for the California Region. Climatic Change 87 (Supplement 1):21-42. DOI: 10.1007/s10584-007-9377-6

Climate Change Science Program [CCSP]. 2008. Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. *In* T.R. Karl, G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (Editors). Department of Commerce, NOAA's National Climate Data Center, Washington, DC.

Conlon, J.M., A. Sonnevend, M. Patel, C. Davidson, P.F. Nielsen, T. Pál, and L.A. Rollins-Smith. 2003. Isolation of Peptides of the Brevinin-1 Family with Potent Candidacidal Activity from the Skin Secretions of the Frog *Rana boylii*. The Journal of Peptide Research 62:207-213.

Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains. Science Advances 1(1):e1400082. DOI: 10.1126/sciadv.1400082

Cook, D.G., S. White, and P. White. 2012. *Rana boylii* (Foothill Yellow-legged Frog) Upland Movement. Herpetological Review 43(2):325-326.

Cordone, A.J., and D.W. Kelley. 1961. The Influence of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game 47(2):189-228.

Corum, S. 2003. Effects of Sacramento Pikeminnow on Foothill Yellow-Legged Frogs in Coastal Streams. Master's Thesis. Humboldt State University, Arcata, CA.

Crayon, J.J. 1998. *Rana catesbeiana* (Bullfrog). Diet. Herpetological Review 29(4):232.

Davidson, C. 2004. Declining Downwind: Amphibian Population Declines in California and Historical Pesticide Use. Ecological Applications 14(6):1892-1902.

Davidson, C., H.B. Shaffer, and M.R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B, and Climate-Change Hypotheses for California Amphibian Declines. Conservation Biology 16(6):1588-1601.

Davidson, C., M.F. Benard, H.B. Shaffer, J.M. Parker, C. O'Leary, J.M. Conlon, and L.A. Rollins-Smith. 2007. Effects of Chytrid and Carbaryl Exposure on Survival, Growth and Skin Peptide Defenses in Foothill Yellow-legged Frogs. Environmental Science and Technology 41(5):1771-1776. DOI: 10.1021/es0611947

Dawson, T.P., S.T. Jackson, J.I. House, I.C. Prentice, and G.M. Mace. 2011. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science 332:53-58.

Dettinger, M., H. Alpert, J. Battles, J. Kusel, H. Safford, D. Fougeres, C. Knight, L. Miller, and S. Sawyer. 2018. Sierra Nevada Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004.

Dever, J.A. 2007. Fine-scale Genetic Structure in the Threatened Foothill Yellow-legged Frog (*Rana boylii*). Journal of Herpetology 41(1):168-173.

Dillingham, C.P., C.W. Koppl, J.E. Drennan, S.J. Kupferberg, A.J. Lind, C.S. Silver, T.V. Hopkins, K.D. Wiseman, and K.R. Marlow. 2018. *In Situ* Population Enhancement of an At-Risk Population of Foothill Yellow-legged Frogs, *Rana boylii*, in the North Fork Feather River, Butte County, California. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Doubledee, R.A., E.B. Muller, and R.M. Nisbet. 2003. Bullfrogs, Disturbance Regimes, and the Persistence of California Red-legged Frogs. Journal of Wildlife Management 67(2):424-438.

Drennan, J.E., K.A. Marlow, K.D. Wiseman, R.E. Jackman, I.A. Chan, and J.L. Lessard. 2015. *Rana boylii* Aging: A Growing Concern. Abstract of paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 8-10 January 2015, Malibu, CA.

Drost, C.A., and G.M. Fellers. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. Conservation Biology 10(2):414-425.

East Contra Costa County Habitat Conservancy [ECCCHC]. 2018. East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan Annual Report 2017.

Ecoclub Amphibian Group, K.L. Pope, G.M. Wengert, J.E. Foley, D.T. Ashton, and R.G. Botzler. 2016. Citizen Scientists Monitor a Deadly Fungus Threatening Amphibian Communities in Northern Coastal California, USA. Journal of Wildlife Diseases 52(3):516-523.

El Dorado Irrigation District [EID]. 2007. Project 184 Foothill Yellow-legged Frog Monitoring Plan.

Electric Consumers Protection Act [ECPA]. 1986. 16 United States Code § 797, 803.

Eriksson A., F. Elías-Wolff, B. Mehlig, and A. Manica. 2014. The Emergence of the Rescue Effect from Explicit Within- and Between-Patch Dynamics in a Metapopulation. Proceedings of the Royal Society B 281:20133127. http://dx.doi.org/10.1098/rspb.2013.3127

Evenden, F.G., Jr. 1948. Food Habitats of *Triturus granulosus* in Western Oregon. Copeia 1948(3):219-220.

Fahrig, L., and G. Merriam. 1985. Habitat Patch Connectivity and Population Survival. Ecology 66(6):1762-1768.

Federal Energy Regulatory Commission [FERC]. 2007a. Order Issuing New License, Project No. 233-081.

Federal Energy Regulatory Commission [FERC]. 2007b. Relicensing Settlement Agreement for the Upper American River Project and Chili Bar Hydroelectric Project.

Federal Energy Regulatory Commission [FERC]. 2009a. Order Amending Forest Service 4(e) Condition 5A, Project No. 1962-187.

Federal Energy Regulatory Commission [FERC]. 2009b. Order Issuing New License, Project No. 2130-033.

Federal Energy Regulatory Commission [FERC]. 2014. Order Issuing New License, Project No. 2101-084.

Federal Energy Regulatory Commission [FERC]. 2018. Final Environmental Impact Statement. Lassen Lodge Hydroelectric Project. Project No. 12496-002.

Federal Energy Regulatory Commission [FERC]. 2019. Active Licenses. FERC eLibrary. Accessed March 10, 2019 at https://www.ferc.gov/industries/hydropower/gen-info/licensing/active-licenses.xls

Fellers, G.M. 2005. *Rana boylii* Baird, 1854(b). Pp. 534-536 *In* M. Lannoo (Editor). Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.

Ferguson, E. 2019. Cultivating Cooperation: Pilot Study Around Headwaters of Mattole River Considers the Effect of Legal Cannabis Cultivators on Northern California Watersheds. Outdoor California 79(1):22-29.

Fidenci, P. 2006. *Rana boylii* (Foothill Yellow-legged Frog) Predation. Herpetological Review 37(2):208.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting Climate Change in California. Ecological Impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, MA, and the Ecological Society of America, Washington, DC.

Fisher, R.N., and H.B. Shaffer. 1996. The Decline of Amphibians in California's Great Central Valley. Conservation Biology 10(5):1387-1397.

Fitch, H.S. 1936. Amphibians and Reptiles of the Rogue River Basin, Oregon. The American Midland Naturalist 17(3):634-652.

Fitch, H.S. 1938. *Rana boylii* in Oregon. Copeia 1938(3):148.

Fitch, H.S. 1941. The Feeding Habits of California Garter Snakes. California Fish and Game 27(2):1-32.

Florsheim, J.L., A. Chin, A.M. Kinoshita, and S. Nourbakhshbeidokhti. 2017. Effect of Storms During Drought on Post-Wildfire Recovery of Channel Sediment Dynamics and Habitat in the Southern California Chaparral, USA. Earth Surface Processes and Landforms 42(1):1482-1492. DOI: 10.1002/esp.4117.

Foe, C.G., and B. Croyle. 1998. Mercury Concentration and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary. Staff report, California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone Hazards to Amphibians and Reptiles. Herpetological Review 25(4):150-153, 156.

Fox, W. 1952. Notes on the Feeding Habits of Pacific Coast Garter Snakes. Herpetologica 8(1):4-8.

Frankham, R. 2005. Genetics and Extinction. Biological Conservation 126:131-140. DOI: 10.1016/j.biocon.2005.05.002

Fuller, D.D., and A.J. Lind. 1992. Implications of Fish Habitat Improvement Structures for Other Stream Vertebrates. Pp. 96-104 *In* Proceedings of the Symposium on Biodiversity of Northwestern California. R. Harris and D. Erman (Editors). Santa Rosa, CA.

Fuller, T.E., K.L. Pope, D.T. Ashton, and H.H. Welsh. 2011. Linking the Distribution of an Invasive Amphibian (*Rana catesbeiana*) to Habitat Conditions in a Managed River System in Northern California. Restoration Ecology 19(201):204-213. DOI: 10.1111/j.1526-100X.2010.00708.x

Furey, P.C., S.J. Kupferberg, and A.J. Lind. 2014. The Perils of Unpalatable Periphyton: *Didymosphenia* and Other Mucilaginous Stalked Diatoms as Food for Tadpoles. Diatom Research 29(3):267-280.

Gaos, A., and M. Bogan. 2001. A Direct Observation Survey of the Lower Rubicon River. California Department of Fish and Game, Rancho Cordova, CA.

Garcia and Associates [GANDA]. 2008. Identifying Microclimatic and Water Flow Triggers Associated with Breeding Activities of a Foothill Yellow-Legged Frog (*Rana boylii*) Population on the North Fork

Feather River, California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-041.

Garcia and Associates [GANDA]. 2017. 2016 Surveys for Foothill Yellow-legged Frog El Dorado County, California for the El Dorado Hydroelectric Project (FERC No. 184) – Job 642-9. Prepared for El Dorado Irrigation District, San Francisco, CA.

Garcia and Associates [GANDA]. 2018. Draft Results of 2017 Surveys for Foothill Yellow-legged Frog (*Rana boylii*) on the Cresta and Poe Reaches of the North Fork Feather River – Job 708/145. Prepared for Pacific Gas and Electric Company, San Francisco, CA.

Geisseler, D., and W.R. Horwath. 2016. Grapevine Production in California. A collaboration between the California Department of Food and Agriculture; Fertilization Education and Research, Project; and University of California, Davis.
https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Grapevine_Production_CA.pdf

Gibbs, J.P., and A.R. Breisch. 2001. Climate Warming and Calling Phenology of Frogs Near Ithaca, New York, 1900-1999. Conservation Biology 15(4):1175-1178.

Gomulkiewicz, R., and R.D. Holt. 1995. When Does Evolution by Natural Selection Prevent Extinction? Evolution 49(1):201-207.

Gonsolin, T.T. 2010. Ecology of Foothill Yellow-legged Frogs in Upper Coyote Creek, Santa Clara County, CA. Master's Thesis. San Jose State University, San Jose, CA.

Grantham, T.E., A.M. Merenlender, and V.H. Resh. 2010. Climatic Influences and Anthropogenic Stressors: An Integrated Framework for Stream Flow Management in Mediterranean-climate California, U.S.A. Freshwater Biology 55(Supplement 1):188-204. DOI: 10.1111/j.1365-2427.2009.02379.x

Green, D.M. 1986a. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Karyological Evidence. Systematic Zoology 35(3):273-282.

Green, D.M. 1986b. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Electrophoretic Evidence. Systematic Zoology 35(3):283-296.

Green Diamond Resource Company [GDRC]. 2018. Mad River Foothill Yellow-legged Frog Egg Mass Surveys Summary Humboldt County, California. Progress report to the California Department of Fish and Wildlife, Wildlife Branch-Nongame Wildlife Program, pursuant to the requirements of Scientific Collecting Permit Entity #6348.

Griffin, D., and K.J. Anchukaitis. 2014. How Unusual is the 2012-2014 California Drought? Geophysical Research Letters 41: 9017-9023. DOI: 10.1002/2014GL062433.

Grinnell, J., and T. I. Storer. 1924. Animal Life in the Yosemite: An Account of the Mammals, Birds, Reptiles, and Amphibians in a Cross-section of the Sierra Nevada. University of California Press, Berkeley, CA.

Grinnell, J., J. Dixon, and J.M. Linsdale. 1930. Vertebrate Natural History of a Section of Northern California Through the Lassen Peak Region. University of California Press, Berkeley, CA.

Haggarty, M. 2006. Habitat Differentiation and Resource Use Among Different Age Classes of Post Metamorphic *Rana boylii* on Red Bank Creek, Tehama County, California. Master's Thesis. Humboldt State University, Arcata, CA.

Hahm, W.J., D.N. Dralle, D.M. Rempe, A.B. Bryk, S.E Thompson, T.E. Dawson, and W.E. Dietrich. 2019. Low Subsurface Water Storage Capacity Relative to Annual Rainfall Decouples Mediterranean Plant Productivity and Water Use from Rainfall Variability. Geophysical Research Letters 46. https://doi.org/10.1029/2019GL083294

Harvey, B.C., and T.E. Lisle. 1998. Effects of Suction Dredging on Streams: A Review and an Evaluation Strategy. Fisheries 23(8):8-17.

Hayes, M.P., and M.R. Jennings. 1986. Decline of Ranid Frog Species in Western North America: Are Bullfrogs (*Rana catesbeiana*) Responsible? Journal of Herpetology 20(4):490-509.

Hayes, M.P., and M.R. Jennings. 1988. Habitat Correlates of Distribution of the California Red-legged Frog (*Rana aurora draytonii*) and the Foothill Yellow-Legged Frog (*Rana boylii*): Implications for Management. Pp. 144-158 *In* Management of Amphibians, Reptiles, and Small Mammals in North America, General Technical Report. RM-166 R.C. Szaro, K.E. Severson, and D.R. Patton (Technical Coordinators). USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hayes, M.P., C.A. Wheeler, A.J. Lind, G.A. Green, and D.C. Macfarlane (Technical Coordinators). 2016. Foothill Yellow-Legged Frog Conservation Assessment in California. Gen. Tech. Rep. PSW-GTR-248. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffle, and A. Vonk. 2003. Atrazine-induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence. Environmental Health Perspectives 11(4):568-575.

Hayes, T.B., P. Case, S. Chui, D. Chung, C. Haeffele, K. Haston, M. Lee, V. P. Mai, Y. Marjuoa, J. Parker, and M. Tsui. 2006. Pesticide Mixtures, Endocrine Disruption, and Amphibian Declines: Are We Underestimating the Impact? Environmental Health Perspectives 114(Supplement 1):40-50.

Hemphill, D.V. 1952. The Vertebrate Fauna of the Boreal Areas of the Southern Yolla Bolly Mountains, California. PhD Dissertation. Oregon State University, Corvallis, OR.

Hey, J., and C. Pinho. 2012. Population Genetics and Objectivity in Species Diagnosis. Evolution 66(5):1413-1429. DOI: 10.1111/j.1558-5646.2011.01542.x

Hillis, D.M., and T.P. Wilcox. 2005. Phylogeny of the New World true frogs (*Rana*). Molecular Phylogenetics and Evolution 34:299-314.

Hoffmann, A.A., and C.M. Sgrò. 2011. Climate Change and Evolutionary Adaptation. Nature 470:479-485. https://www.nature.com/articles/nature09670

Hogan, S., and C. Zuber. 2012. North Fork American River 2012 Summary Report. California Department of Fish and Wildlife Heritage and Wild Trout Program, Rancho Cordova, CA.

Hopkins, G.R., S.S. French, and E.D. Brodie. 2013. Increased Frequency and Severity of Developmental Deformities in Rough-skinned Newt (*Taricha granulosa*) Embryos Exposed to Road Deicing Salts (NaCl & $MgCl_2$). Environmental Pollution 173:264-269. http://dx.doi.org/10.1016/j.envpol.2012.10.002

Hothem, R.L., A.M. Meckstroth, K.E. Wegner, M.R. Jennings, and J.J. Crayon. 2009. Diets of Three Species of Anurans from the Cache Creek Watershed, California, USA. Journal of Herpetology 43(2):275-283.

Hothem, R.L., M.R. Jennings, and J.J. Crayon. 2010. Mercury Contamination in Three Species of Anuran Amphibians from the Cache Creek Watershed, California, USA. Environmental Monitoring and Assessment 163:433-448. https://doi.org/10.1007/s10661-009-0847-3

Hughes, A.R., B.D. Inouye, M.T.J. Johnson, N. Underwood, and M. Vellend. 2008. Ecological Consequences of Genetic Diversity. Ecology Letters 11:609-623. DOI: 10.1111/j.1461-0248.2008.01179.x

Humboldt Redwood Company [HRC]. 2015. Habitat Conservation Plan for the Properties of The Pacific Lumber Company, Scotia Pacific Holding Company, and Salmon Creek Corporation under the Ownership and Management of Humboldt Redwood Company, LLC, as of July 2008. Established February 1999, Revised 12 August 2015.

ICF International. 2012. Final Santa Clara Valley Habitat Plan. https://scv-habitatagency.org/178/Santa-Clara-Valley-Habitat-Plan

Jackman, R.E., J.E. Drennan, K.R. Marlow, and K.D. Wiseman. 2004. Some Effects of Spring and Summer Pulse Flows on River-breeding Foothill Yellow-legged Frogs (*Rana boylii*) along the North Fork Feather River. Abstract of paper presented at the Cal-Neva and Humboldt Chapters of the American Fisheries Society Annual Meeting 23 April 2004, Redding, CA.

Jennings, M.R., and M.P. Hayes. 1985. Pre-1900 Overharvest of California Red-Legged Frogs (*Rana aurora draytonii*): The Inducement for Bullfrog (*Rana catesbeiana*) Introduction. Herpetologica 41(1):94-103.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Contract No. 8023. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA.

Jennings, M.R., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Coloration. Herpetological Review 36(4):438.

Jones & Stokes Associates. 2006. East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan.

Karraker, N.E., J.P. Gibbs, and J.R. Vonesh. 2008. Impacts of Road Deicing Salt on the Demography of Vernal Pool-breeding Amphibians. Ecological Applications 18(3):724-734.

Kats, L.B., and R.P. Ferrer. 2003. Alien Predators and Amphibian Declines: Review of Two Decades of Science and the Transition to Conservation. Diversity and Distributions 9(2):99-110.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streambank Management Implications…A review. Journal of Range Management 37(5):430-437.

Kauffman, J.B., W.C. Krueger, and M. Varva. 1983. Impacts of Cattle on Streambanks in Northeastern Oregon. Journal of Range Management 36(6):683-685.

Keeley, J.E. 2005. Fire History of the San Francisco East Bay Region and Implications for Landscape Patterns. International Journal of Wildland Fire 14:285-296.

Keeley, J.E., and A.D. Syphard. 2016. Climate Change and Future Fire Regimes: Examples from California. Geosciences 6(7):37. DOI: 10.3390/geosciences6030037

Kerby, J.L., S.P. Riley, L.B. Kats, and P. Wilson. 2005. Barriers and Flow as Limiting Factors in the Spread of an Invasive Crayfish (*Procambarus clarkii*) in southern California streams. Biological Conservation 126(3):402-409.

Kerby, J.L., and A. Sih. 2015. Effects of Carbaryl on Species Interactions of the Foothill Yellow Legged Frog (*Rana boylii*) and the Pacific Treefrog (*Pseudacris regilla*). Hydrobiologia 746(1):255-269. DOI: 10.1007/s10750-014-2137-5

Kiesecker, J.M. 2002. Synergism Between Trematode Infection and Pesticide Exposure: A Link to Amphibian Limb Deformities in Nature? PNAS 99(15):9900-9904. https://doi.org/10.1073/pnas.152098899

Kiesecker, J.M., and A.R. Blaustein. 1997. Influences of Egg Laying Behavior on Pathogenic Infection of Amphibian Eggs. Conservation Biology 11(1):214-220.

Knowles, N., M.D. Dettinger, and D.R. Cayan. 2006. Trends in Snowfall Versus Rainfall in the Western United States. Journal of Climate 19(18):4545-4559. https://doi.org/10.1175/JCLI3850.1

Kupferberg, S.J. 1996a. Hydrologic and Geomorphic Factors Affecting Conservation of a River-Breeding Frog (*Rana boylii*). Ecological Applications 6(4):1322-1344.

Kupferberg, S.J. 1996b. The Ecology of Native Tadpoles (*Rana boylii* and *Hyla regilla*) and the Impact of Invading Bullfrogs (*Rana catesbeiana*) in a Northern California River. PhD Dissertation. University of California, Berkeley.

Kupferberg, S.J. 1997a. Bullfrog (*Rana catesbeiana*) Invasion of a California River: The Role of Larval Competition. Ecology 78(6):1736-1751.

Kupferberg, S.J. 1997b. The Role of Larval Diet in Anuran Metamorphosis. American Zoology 37:146-159.

Kupferberg, S., and A. Catenazzi. 2019. Between Bedrock and a Hard Place: Riverine Frogs Navigate Tradeoffs of Pool Permanency and Disease Risk During Drought. Abstract prepared for the Joint Meeting of Ichthyologists and Herpetologists. 24-28 July 2019, Snowbird, UT.

Kupferberg, S.J., A. Catenazzi, K. Lunde, A. Lind, and W. Palen. 2009a. Parasitic Copepod (*Lernaea cyprinacea*) Outbreaks in Foothill Yellow-legged Frogs (*Rana boylii*) Linked to Unusually Warm Summers and Amphibian Malformations in Northern California. Copeia 2009(3):529-537.

Kupferberg, S.J., A. Catenazzi, and M.E. Power. 2011a. The Importance of Water Temperature and Algal Assemblage for Frog Conservation in Northern California Rivers with Hydroelectric Projects. Final Report to the California Energy Commission, PIER. CEC-500-2014-033.

Kupferberg, S.J., and P.C. Furey. 2015. An Independent Impact Analysis using Carnegie State Vehicular Recreation Area Habitat Monitoring System Data. Friends of Tesla Park Technical Memorandum. DOI: 10.13140/RG.2.1.4898.9207

Kupferberg, S.J., A. Lind, J. Mount, and S. Yarnell. 2009b. Pulsed Flow Effects on the Foothill Yellow-Legged Frog (*Rana boylii*): Integration of Empirical, Experimental, and Hydrodynamic Modeling Approaches. Final Report. California Energy Commission, PIER. CEC-500-2009-002.

Kupferberg, S.J., A.J. Lind, and W.J. Palen. 2009c. Pulsed Flow Effects on the Foothill Yellow-legged Frog (*Rana boylii*): Population Modeling. Final Report to the California Energy Commission, PIER. CEC-500-2009-002a.

Kupferberg, S.J., A.J. Lind, V. Thill, and S.M. Yarnell. 2011b. Water Velocity Tolerance in Tadpoles of the Foothill Yellow-legged Frog (*Rana boylii*): Swimming Performance, Growth, and Survival. Copeia 2011(1):141-152.

Kupferberg, S.J., W.J. Palen, A.J. Lind, S. Bobzien, A. Catenazzi, J. Drennan, and M.E. Power. 2012. Effects of Flow Regimes Altered by Dams on Survival, Population Declines, and Range-wide Losses of California River-Breeding Frogs. Conservation Biology 26(3):513-524.

Lambert, M.R., T. Tran, A. Kilian, T. Ezaz, and D.K. Skelly. 2019. Molecular Evidence for Sex Reversal in Wild populations of Green Frogs (*Rana clamitans*). PeerJ 7:e6449. DOI: 10.7717/peerj.6449

Lande, R., and S. Shannon. 1996. The Role of Genetic Variation in Adaptation and Population Persistence in a Changing Environment. Evolution 50(1):434-437.

Leidy, R.A., E. Gonsolin, and G.A. Leidy. 2009. Late-summer Aggregation of the Foothill Yellow-legged Frog (*Rana boylii*) in Central California. The Southwestern Naturalist 54(3):367-368.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, and J.N. Seiber. 1999. Summertime Transport of Current-Use Pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. Environmental Toxicology and Chemistry 18(12):2715-2722.

Lind, A.J. 2005. Reintroduction of a Declining Amphibian: Determining an Ecologically Feasible Approach for the Foothill Yellow-legged Frog (*Rana boylii*) Through Analysis of Decline Factors, Genetic Structure, and Habitat Associations. PhD Dissertation. University of California, Davis.

Lind, A.J., J.B. Bettaso, and S.M. Yarnell. 2003a. Natural History Notes: *Rana boylii* (Foothill Yellow-legged Frog) and *Rana catesbeiana* (Bullfrog). Reproductive behavior. Herpetological Review 34(3):234-235.

Lind, A.J., L. Conway, H. (Eddinger) Sanders, P. Strand, and T. Tharalson. 2003b. Distribution, Relative Abundance, and Habitat of Foothill Yellow-legged Frogs (*Rana boylii*) on National Forests in the Southern Sierra Nevada Mountains of California. Report to the FHR Program of Region 5 of the USDA Forest Service.

Lind, A.J., P.Q. Spinks, G.M. Fellers, and H.B. Shaffer. 2011. Rangewide Phylogeography and Landscape Genetics of the Western U.S. Endemic Frog *Rana boylii* (Ranidae): Implications for the Conservation of Frogs and Rivers. Conservation Genetics 12:269-284.

Lind, A.J., and H.H. Welsh, Jr. 1994. Ontogenetic Changes in Foraging Behaviour and Habitat Use by the Oregon Garter Snake, *Thamnophis atratus hydrophilus*. Animal Behaviour 48:1261-1273.

Lind, A.J., H.H. Welsh, Jr., and C.A. Wheeler. 2016. Foothill Yellow-legged Frog (*Rana boylii*) Oviposition Site Choice at Multiple Spatial Scales. Journal of Herpetology 50(2):263-270.

Lind, A.J., H.H. Welsh, Jr., and R.A. Wilson. 1996. The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii*) in Northwestern California. Herpetological Review 27(2):62-67.

Little, E.E., and R.D. Calfee. 2000. The Effects of UVB Radiation on the Toxicity of Fire-Fighting Chemicals. Final Report. U.S. Geological Service, Columbia Environmental Research Center, Columbia, MO.

Loomis, R.B. 1965. The Yellow-legged Frog, *Rana boylei*, from the Sierra San Pedro Mártir, Baja California Norte, México. Herpetologica 21(1):78-80.

Lowe, J. 2009. Amphibian Chytrid (*Batrachochytrium dendrobatidis*) in Postmetamorphic *Rana boylii* in Inner Coast Ranges of Central California. Herpetological Review 40(2):180.

Macey, R.J., J.L. Strasburg, J.A. Brisson, V.T. Vredenburg, M. Jennings, and A. Larson. 2001. Molecular Phylogenetics of Western North American Frogs of the *Rana boylii* Species Group. Molecular Phylogenetics and Evolution 19(1):131-143.

MacTague, L., and P.T. Northen. 1993. Underwater Vocalization by the Foothill Yellow-Legged Frog (*Rana boylii*). Transactions of the Western Section of the Wildlife Society 29:1-7.

Mallakpour, I., M. Sadegh, and A. AghaKouchak. 2018. A New Normal for Streamflow in California in a Warming Climate: Wetter Wet Seasons and Drier Dry Seasons. Journal of Hydrology 567:203-211.

Mallery, M. 2010. Marijuana National Forest: Encroachment on California Public Lands for Cannabis Cultivation. Berkeley Undergrad Journal 23(2):1-50. http://escholarship.org/uc/item/7r10t66s#page-2

Marlow, C.B., and T.M. Pogacnik. 1985. Time of Grazing and Cattle-Induced Damage to Streambanks. Pp. 279-284 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Marlow, K.R., K.D. Wiseman, C.A. Wheeler, J.E. Drennan, and R.E. Jackman. 2016. Identification of Individual Foothill Yellow-legged Frogs (*Rana boylii*) using Chin Pattern Photographs: A Non-Invasive and Effective Method for Small Population Studies. Herpetological Review 47(2):193-198.

Martin, C. 1940. A New Snake and Two Frogs for Yosemite National Park. Yosemite Nature Notes 19(11):83-85.

Martin, P.L., R.E. Goodhue, and B.D. Wright. 2018. Introduction. Pp. 1-25 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/07/5c/075c8120-3705-4a79-ae74-130fdfe46c6b/introduction.pdf

McCartney-Melstad, E., M. Gidiş, and H.B. Shaffer. 2018. Population Genomic Data Reveal Extreme Geographic Subdivision and Novel Conservation Actions for the Declining Foothill Yellow-legged Frog. Heredity 121:112-125.

McCartney-Melstad, E., and H.B. Shaffer. 2015. Amphibian Molecular Ecology and How It Has Informed Conservation. Molecular Ecology 24:5084-5109. DOI: 10.1111/mec.13391

Megahan, W.F., J.G. King, and K.A. Seyedbagheri. 1995. Hydrologic and Erosional Responses of a Granitic Watershed to Helicopter Logging and Broadcast Burning. Forest Science 41(4):777-795.

Merenlender, A.M. 2000. Mapping Vineyard Expansion Provides Information on Agriculture and the Environment. California Agriculture 54(3):7-12.

Mierau, D.W., W.J. Trush, G.J. Rossi, J.K. Carah, M.O. Clifford, and J.K. Howard. 2017. Managing Diversions in Unregulated Streams using a Modified Percent-of-Flow Approach. Freshwater Biology 63:752-768. DOI: 10.1111/fwb.12985

Moritz, C., J.L. Patton, C.J. Conroy, J.L. Parra, G.C. White, and S.R. Beissinger. 2008. Impact of a Century of Climate Change on Small-Mammal Communities in Yosemite National Park, USA. Science 322:261-264.

Moyle, P.B. 1973. Effects of Introduced Bullfrogs, *Rana catesbeiana*, on the Native Frogs of the San Joaquin Valley, California. Copeia 1973(1):18-22.

Moyle, P.B., and P.J. Randall. 1998. Evaluating the Biotic Integrity of Watersheds in the Sierra Nevada, California. Conservation Biology 12(6):1318-1326.

Napa County. 2010. Napa County Voluntary Oak Woodlands Management Plan.

National Integrated Drought Information System [NIDIS]. 2019. Drought in California from 2000-2019. National Drought Mitigation Center, U.S. Department of Agriculture Federal Drought Assistance. Accessed 25 April 2019 at https://www.drought.gov/drought/states/california

National Marine Fisheries Service [NMFS]. 2012. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office, Sacramento, CA.

National Marine Fisheries Service [NMFS]. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, CA.

Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians & Reptiles of the Pacific Northwest. University Press of Idaho, Moscow, ID.

Off-Highway Motor Vehicle Recreation Commission [OHMVRC]. 2017. Off-Highway Motor Vehicle Recreation Commission Program Report, January 2017. http://ohv.parks.ca.gov/pages/1140/files/OHMVR-Commission-2017-Program_Report-FINAL-Mar2017_web.pdf

Office of Environmental Health Hazard Assessment [OEHAA], California Environmental Protection Agency. 2018. Indicators of Climate Change in California. https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

Olson, D.H., and R. Davis. 2009. Conservation Assessment for the Foothill Yellow-legged Frog (*Rana boylii*) in Oregon. USDA Forest Service Region 6 and USDI Bureau of Land Management Interagency Special Status Species Program.

Olson, E.O., J.D. Shedd, and T.N. Engstrom. 2016. A Field Inventory and Collections Summary of Herpetofauna from the Sutter Buttes, an "Inland Island" within California's Great Central Valley. Western North American Naturalist 76(3):352-366.

Pacific Gas and Electric [PG&E]. 2018. Pit 3, 4, and 5 Hydroelectric Project (FERC Project No. 233) Foothill Yellow-Legged Frog Monitoring 2017 Annual Report.

Padgett-Flohr, G.E., and R.L. Hopkins. 2009. *Batrachochytrium dendrobatidis*, a Novel Pathogen Approaching Endemism in Central California. Diseases of Aquatic Organisms 83:1-9.

Palstra, F.P., and D.E. Ruzzante. 2008. Genetic Estimates of Contemporary Effective Population Size: What Can They Tell Us about the Importance of Genetic Stochasticity for Wild Population Persistence? Molecular Ecology 17:3428-3447. DOI: 10.1111/j.1365-294X.2008.03842.x

Paoletti, D.J., D.H. Olson, and A.R. Blaustein. 2011. Responses of Foothill Yellow-legged Frog (*Rana boylii*) Larvae to an Introduced Predator. Copeia 2011(1):161-168.

Parks, S.A., C. Miller, J.T. Abatzoglou, L.M. Holsinger, M-A. Parisien, and S.Z. Dobrowski. 2016. How Will Climate Change Affect Wildland Fire Severity in the Western US? Environmental Research Letters 11:035002. DOI: 10.1088/1748-9326/11/3/035002

Parmesan, C., and G. Yohe. 2003. A Globally Coherent Fingerprint of Climate Change Impacts across Natural Systems. Nature 421(6918):37-42. DOI: 10.1038/nature01286

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs Call at a Higher Pitch in Traffic Noise. Ecology and Society 12(1):25. http://www.ecologyandsociety.org/vol14/iss1/art25/

Peek, R.A. 2010. Landscape Genetics of Foothill Yellow-legged Frogs (*Rana boylii*) in Regulated and Unregulated Rivers: Assessing Connectivity and Genetic Fragmentation. Master's Thesis. University of San Francisco, San Francisco, CA.

Peek, R.A. 2018. Population Genetics of a Sentinel Stream-breeding Frog (*Rana boylii*). PhD Dissertation. University of California, Davis.

Peek, R., and S. Kupferberg. 2016. Assessing the Need for Endangered Species Act Protection of the Foothill Yellow-legged Frog (*Rana boylii*): What do Breeding Censuses Indicate? Poster, and poster abstract, presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 7-8 January 2016, Davis, CA.

Pilliod, D.S., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and Amphibians in North America. Forest Ecology and Management 178:163-181.

Placer County Water Agency [PCWA]. 2008. Final AQ 12 – Special-Status Amphibian and Aquatic Reptile Technical Study Report – 2007. Placer County Water Agency Middle Fork American River Project (FERC No. 2079), Auburn, CA.

Pounds, A., A.C.O.Q. Carnaval, and S. Corn. 2007. Climate Change, Biodiversity Loss, and Amphibian Declines. Pp. 19-20 *In* C. Gascon, J.P. Collins, R.D. Moore, D.R. Church, J.E. McKay, and J.R. Mendelson III (Editors). IUCN Amphibian Conservation Action Plan, Proceedings: IUCN/SSC Amphibian Conservation Summit 2005.

Powell, R., R. Conant, and J.T. Collins. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central America, Fourth Edition.

Power, M.E., M.S. Parker, and W.E. Dietrich. 2008. Seasonal Reassembly of a River Food Web: Floods, Droughts, and Impacts of Fish. Ecological Monographs 78(2):263-282.

Prado, M. 2005. Rare Frogs Put at Risk by Visitors in West Marin. Marin Independent Journal. Newspaper article, May 09, 2005.

Public Policy Institute of California [PPIC]. 2018. Storing Water. https://www.ppic.org/publication/californias-water-storing-water/

Public Policy Institute of California [PPIC]. 2019. California's Future: Population. https://www.ppic.org/wp-content/uploads/californias-future-population-january-2019.pdf

Radeloff, V.C., D.P. Helmers, H.A. Kramer, M.H. Mockrin, P.M. Alexandre, A. Bar-Massada, V. Butsic, T.J. Hawbaker, S. Martinuzzi, A.D. Syphard, and S.I. Stewart. 2018. Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk. PNAS 115(13):3314-3319. https://doi.org/10.1073/pnas.1718850115

Railsback, S.F., B.C. Harvey, S.J. Kupferberg, M.M. Lang, S. McBain, and H.H. Welsh, Jr. 2016. Modeling Potential River Management Conflicts between Frogs and Salmonids. Canadian Journal of Fisheries and Aquatic Sciences 73:773-784.

Reeder, N.M.M., A.P. Pessier, and V.T. Vredenburg. 2012. A Reservoir Species for the Emerging Amphibian Pathogen *Batrachochytrium dendrobatidis* Thrives in a Landscape Decimated by Disease. PLoS ONE 7(3):e33567. https://doi.org/10.1371/journal.pone.0033567

Riegel, J.A. 1959. The Systematics and Distribution of Crayfishes in California. California Fish and Game 45:29-50.

Relyea, R.A. 2005. The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Ecological Applications 15(2):618-627.

Relyea, R.A., and N. Diecks. 2008. An Unforeseen Chain of Events: Lethal Effects of Pesticides on Frogs at Sublethal Concentrations. Ecological Applications 18(7):1728-1742.

Rombough, C. 2006. Winter Habitat Use by Juvenile Foothill Yellow-legged Frogs (*Rana boylii*): The Importance of Seeps. *In* Abstracts from the 2006 Annual Meetings of the Society for Northwestern Vertebrate Biology and the Washington Chapter of the Wildlife Society. Northwest Naturalist 87(2):159.

Rombough, C.J., J. Chastain, A.M. Schwab, and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(4):438-439.

Rombough, C.J., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation: Eggs and Hatchlings. Herpetological Review 36(2):163-164.

Rombough, C.J., and M.P. Hayes. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Reproduction. Herpetological Review 38(1):70-71.

Russell, K.R., D.H. Van Lear, and D.C. Guynn, Jr. 1999. Prescribed Fire Effects on Herpetofauna: Review and Management Implications. Wildlife Society Bulletin 27(2):374-384.

San Joaquin Council of Governments, Inc. [SJCOG 2018]. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2018 Annual Report.

San Joaquin County. 2000. San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan.

Santa Clara Valley Habitat Agency [SCVHA]. 2019. Santa Clara Valley Habitat Plan 4th Annual Report FY2017-2018.

Scheele, B.C., F. Pasmans, L.F. Skerratt, L. Berger, A. Martel, W. Beukema, A.A. Acevedo, P.A. Burrows, T. Carvalhos, A. Catenazzi, I. De la Riva, M.C. Fisher, S.V. Flechas, C.N. Foster, P. Frías-Álvarez, T.W.J. Garner, B. Gratwicke, J.M. Guayasamin, M. Hirschfeld, J.E. Kolby, T.A. Kosch, E. La Marca, D.B. Lindenmayer, K.R. Lips, A.V. Longo, R. Maneyro, C.A. McDonald, J. Mendelson III, P. Palacios-Rodriguez, G. Parra-Olea, C.L. Richards-Zawacki, M-O. Rödel, S.M. Rovito, C. Soto-Azat, L.F. Toledo, J. Voyles, C. Weldon, S.M. Whitfield, M. Wilkinson, K.R. Zamudio, and S. Canessa. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. Science 363(6434):1459-1463. DOI: 10.1126/science.aav0379

Siekert, R.E., Q.D. Skinner, M.A. Smith, J.L. Dodd, and J.D. Rogers. 1985. Channel Response of an Ephemeral Stream in Wyoming to Selected Grazing Treatments. Pp. 276-278 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Silver, C.S. 2017. Population-level Variation in Vocalizations of *Rana boylii*, the Foothill Yellow-legged Frog. Master's Thesis. California State University, Chico, Chico, CA.

Snover, M.L., and M.J. Adams. 2016. Herpetological Monitoring and Assessment on the Trinity River, Trinity County, California-Final Report: U.S. Geological Survey Open-File Report 2016-1089. http://dx.doi.org/10.3133/ofr20161089

Sparling, D.W., and G.M. Fellers. 2007. Comparative Toxicity of Chlorpyrifos, Diazinon, Malathion and Their Oxon Derivatives to *Rana boylii*. Environmental Pollution 147:535-539.

Sparling, D.W., and G.M. Fellers. 2009. Toxicity of Two Insecticides to California, USA, Anurans and Its Relevance to Declining Amphibian Populations. Environmental Toxicology and Chemistry 28(8):1696-1703.

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and Amphibian Declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.

Spencer, C.N., and F.R. Hauer. 1991. Phosphorus and Nitrogen Dynamics in Streams During a Wildfire. Journal of the North American Benthological Society 10(1):24-30.

Spring Rivers Ecological Sciences. 2003. Foothill Yellow-legged Frog (*Rana boylii*) Studies in 2002 for Pacific Gas and Electric Company's Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233). Pacific Gas and Electric Company, Technical and Ecological Services, San Ramon, CA.

State Board of Forestry and Fire Protection [SBFFP]. 2018. 2018 Strategic Fire Plan for California. Accessed March 1, 2019 at http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf1614.pdf

State Water Resources Control Board [SWRCB]. 2017. Water Quality Certification for the Pacific Gas and Electric Company Poe Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2107.

State Water Resources Control Board [SWRCB]. 2018. Water Quality Certification for the South Feather Water and Power Agency South Feather Power Project, Federal Energy Regulatory Commission Project No. 2088.

State Water Resources Control Board [SWRCB]. 2019. February 2019 Executive Director's Report. Accessed February 18, 2019 at https://www.waterboards.ca.gov/board_info/exec_dir_rpts/2019/ed_rpt_021119.pdf

Stebbins, R.C. 2003. Peterson Filed Guides Western Reptiles and Amphibians. Third Edition. Houghton Mifflin Company, Boston, MA.

Stebbins, R.C., and S.M. McGinnis. 2012. Field Guide to Amphibians and Reptiles of California. Revised Edition. University of California Press, Berkeley, CA.

Stephens, S.L., N. Burrows, A. Buyantuyev, R.W. Gray, R.E. Keane, R. Kubian, S. Liu, F. Seijo, L. Shu, K.G. Tolhurst, and J.W. van Wagtendonk. 2014. Temperate and Boreal Forest Mega-Fires: Characteristics and Challenges. Frontiers in Ecology and the Environment 12(2):115-122.

Stephens, S.L, J.D. McIver, R.E.J. Boerner, C.J. Fettig, J.B. Fontaine, B.R. Hartsough, P.I. Kennedy, and D.W. Schwilk. 2012. The Effects of Forest Fuel-Reduction Treatments in the United States. BioScience 62(6):549-560.

Stewart, I.T. 2009. Changes in Snowpack and Snowmelt Runoff for Key Mountain Regions. Hydrological Processes 23:78-94. DOI: 10.1002/hyp.7128

Stillwater Sciences. 2012. Analysis of Long-term River Regulation Effects on Genetic Connectivity of Foothill Yellow-legged Frogs (*Rana boylii*) in the Alameda Creek Watershed. Final Report. Prepared by Stillwater Sciences, Berkeley, CA for SFPUC, San Francisco, CA.

Stopper, G.F., L. Hecker, R.A. Franssen, and S.K. Sessions. 2002. How Trematodes Cause Limb Deformities in Amphibians. Journal of Experimental Zoology Part B (Molecular and Developmental Evolution) 294:252-263.

Storer, T.I. 1923. Coastal Range of Yellow-legged Frog in California. Copeia 114:8.

Storer, T.I. 1925. A Synopsis of the Amphibia of California. University of California Publication Zoology 27:1-342.

Sweet, S.S. 1983. Mechanics of a Natural Extinction Event: *Rana boylii* in Southern California. Abstract of paper presented at the Joint Annual Meeting of the Herpetologists' League and Society for the Study of Amphibians and Reptiles 7-12 August 1983, Salt Lake City, UT.

Syphard, A.D., V.C. Radeloff, T.J. Hawbaker, and S.I. Stewart. 2009. Conservation Threats Due to Human-Caused Increases in Fire Frequency in Mediterranean-Climate Ecosystems. Conservation Biology 23(3):758–769. DOI: 10.1111/j.1523-1739.2009.01223.x

Syphard, A.D., V.C. Radeloff, J.E. Keeley, T.J. Hawbaker, M.K. Clayton, S.I. Stewart, and R.B. Hammer. 2007. Human Influence on California Fire Regimes. Ecological Applications 17(5):1388-1402.

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573.

Thompson, C., R. Sweitzer, M. Gabriel, K. Purcell, R. Barrett, and R. Poppenga. 2014. Impacts of Rodenticide and Insecticide Toxicants from Marijuana Cultivation Sites on Fisher Survival Rates in the Sierra National Forest, California. Conservation Letters 7(2):91-102.

Thomson, R.C., A.N. Wright, and H.B. Shaffer. 2016. California Amphibian and Reptile Species of Special Concern. University of California Press, Berkeley, CA.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

Tracey, J.A., C.J. Rochester, S.A. Hathaway, K.L. Preston, A.D. Syphard, A.G. Vandergast, J.E. Diffendorfer, J. Franklin, J.B. MacKenzie, T.A. Oberbauer, S. Tremor, C.S. Winchell, and R.N. Fisher. 2018. Prioritizing Conserved Areas Threatened by Wildfire and Fragmentation for Monitoring and Management. PLoS ONE 13(9):e0200203. https://doi.org/10.1371/journal.pone.0200203

Troïanowski, M., N. Mondy, A. Dumet, C. Arcajo, and T. Lengagne. 2017. Effects of Traffic Noise on Tree Frog Stress Levels, Immunity, and Color Signaling. Conservation Biology 31(5):1132-1140.

Twitty, V.C., D. Grant, and O. Anderson. 1967. Amphibian Orientation: An Unexpected Observation. Science 155(3760):352-353.

Unrine, J.M., C.H. Jagoe, W.A. Hopkins, and H.A. Brant. 2004. Adverse Effects of Ecologically Relevant Dietary Mercury Exposure in Southern Leopard Frog (*Rana sphenocephala*) Larvae. Environmental Toxicology and Chemistry 23(12):2964-2970.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2004. Sierra Nevada Forest Plan Amendment. Final Supplemental Environmental Impact Statement, Record of Decision.

U.S. Department of Agriculture, Forest Service [USDA FS] and Bureau of Land Management [BLM]. 1994. Standards and guidelines for management of habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl.

U.S. Fish and Wildlife Service [USFWS]. 1998. Recovery Plan for the Shasta Crayfish (*Pacifastacus fortis*). U.S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service [USFWS]. 2015. Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions. Federal Register 80(126):37568-37579.

U.S. Fish and Wildlife Service [USFWS] and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report. U.S. Fish and Wildlife Service, Arcata, CA.

Van Wagner, T.J. 1996. Selected Life-History and Ecological Aspects of a Population of Foothill Yellow-legged Frogs (*Rana boylii*) from Clear Creek, Nevada County, California. Master's Thesis. California State University Chico, Chico, CA.

Volpe, R.J., III, R. Green, D. Heien, and R. Howitt. 2010. Wine-Grape Production Trends Reflect Evolving Consumer Demand over 30 Years. California Agriculture 64(1):42-46.

Vredenburg, V.T., R. Bingham, R. Knapp, J.A.T. Morgan, C. Moritz, and D. Wake. 2007. Concordant Molecular and Phenotypic Data Delineate New Taxonomy and Conservation Priorities for the Endangered Mountain Yellow-legged Frog. Journal of Zoology 271:361-374. DOI: 10.1111/j.1469-7998.2006.00258.x

Wang, I.J., J.C. Brenner, and V. Butsic. 2017. Cannabis, an Emerging Agricultural Crop, Leads to Deforestation and Fragmentation. Frontiers in Ecology and the Environment 15(9):495-501. DOI: 10.1002/fee.1634

Warren, D.L., A.N. Wright, S.N. Seifert, and H.B. Shaffer. 2014. Incorporating Model Complexity and Spatial Sampling Bias into Ecological Niche Models of Climate Change Risks Faced by 90 California Vertebrate Species of Concern. Diversity and Distributions 20:334-343. DOI: 10.1111/ddi.12160

Welsh, H.H., Jr., and G.R. Hodgson. 2011. Spatial Relationships in a Dendritic Network: The Herpetofaunal Metacommunity of the Mattole River Catchment of Northwest California. Ecography 34:49-66. DOI: 10.1111/j.1600-0587.2010.06123.x

Welsh, H.H., Jr., G.R. Hodgson, and A.J. Lind. 2005. Ecography of the Herpetofauna of a Northern California Watershed: Linking Species Patterson to Landscape Processes. Ecography 23:521-536.

Welsh, H.H., Jr., and L.M. Ollivier. 1998. Stream Amphibians as Indicators of Ecosystem Stress: A Case Study from California's Redwoods. Ecological Applications 8(4):1118-1132.

Werschkul, D.F., and M.T. Christensen. 1977. Differential Predation by *Lepomis macrochirus* on the Eggs and Tadpoles of *Rana*. Herpetologica 33(2):237-241.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Science 313(5789):940-943. DOI: 10.1126/science.1128834

Wheeler, C.A., J.B. Bettaso, D.T. Ashton and H.H. Welsh, Jr. 2014. Effects of Water Temperature on Breeding Phenology, Growth, and Metamorphosis of Foothill Yellow-legged Frogs (*Rana boylii*): A Case Study of the Regulated Mainstem and Unregulated Tributaries of California's Trinity River. River Research and Applications 31:1276-1286. DOI: 10.1002/rra.2820

Wheeler, C.A., J.M. Garwood, and H.H. Welsh, Jr. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Physiological Skin Color Transformation. Herpetological Review 36(2):164-165.

Wheeler, C.A., A.J. Lind, H.H. Welsh, Jr., and A.K. Cummings. 2018. Factors that Influence the Timing of Calling and Oviposition of a Lotic Frog in Northwestern California. Journal of Herpetology 52(3):289-298.

Wheeler, C.A., and H.H. Welsh, Jr. 2008. Mating Strategy and Breeding Patterns of the Foothill Yellow-legged Frog (*Rana boylii*). Herpetological Conservation and Biology 3(2):128-142.

Wheeler, C.A., H.H. Welsh, Jr., and T. Roelofs. 2006. Oviposition Site Selection, Movement, and Spatial Ecology of the Foothill Yellow-legged Frog (*Rana boylii*). Final Report to the California Department of Fish and Game Contract No. P0385106, Sacramento, CA.

Wilcox, J.T., and J.A. Alvarez. 2019. Wrestling for Real Estate: Male-Male Interactions in Breeding Foothill Yellow-legged Frogs (*Rana boylii*). Western Wildlife 6:14-17.

Williams, A.P., R. Seager, J.T. Abatzoglou, B.I. Cook, J.E. Smerdon, and E.R. Cook. 2015. Contribution of Anthropogenic Warming to California Drought During 2012–2014. Geophysical Research Letters 42:6819-6828. DOI: 10.1002/2015GL064924

Williams S.E., L.P. Shoo, J.L. Isaac, A.A. Hoffmann, and G. Langham. 2008. Towards an Integrated Framework for Assessing the Vulnerability of Species to Climate Change. PLoS Biol 6(12):e325. DOI: 10.1371/journal.pbio.0060325

Wiseman, K.D., and J. Bettaso. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Cannibalism and Predation. Herpetological Review 38(2):193.

Wiseman, K.D., K.R. Marlow, R.E. Jackman, and J.E. Drennan. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(2):162-163.

Wright, A.N., R.J. Hijmans, M.W. Schwartz, and H.B. Shaffer. 2013. California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change. Final Report to the California Department of Fish and Wildlife. Contract No. P0685904, Sacramento, CA.

Yap, T.A., M.S. Koo, R.F. Ambrose, and V.T. Vredenburg. 2018. Introduced Bullfrog Facilitates Pathogen Invasion in the Western United States. PLoS ONE 13(4):e0188384. https://doi.org/10.1371/journal.pone.0188384

Yarnell, S.M. 2005. Spatial Heterogeneity of *Rana boylii* Habitat: Physical Properties, Quantification and Ecological Meaningfulness. PhD Dissertation. University of California, Davis.

Yarnell, S.M., R.A. Peek, D. Rheinheimer, A. Lind, J.H. Viers. 2013. Management of the Spring Snowmelt Recession: An Integrated Analysis of Empirical, Hydrodynamic, and Hydropower Modeling Applications. California Energy Commission. Publication number: CEC-500-2014-030. https://ww2.energy.ca.gov/2014publications/CEC-500-2014-030/CEC-500-2014-030.pdf

Yarnell, S.M., J.H. Viers, and J.F. Mount. 2010. Ecology and Management of the Spring Snowmelt Recession. Bioscience 60(2):114-127.

Yoon, J-H., S-Y.S. Wang, R.R. Gillies, B. Kravitz, L. Hipps, and P.J. Rasch. 2015. Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle under Global Warming. Nature Communications 6:8657. DOI: 10.1038/ncomms9657

Young, C.A., M. Escobar, M. Fernandes, B. Joyce, M. Kiparsky, J.F. Mount, V. Mehta, J.H. Viers, and D. Yates. 2009. Modeling the Hydrology of California's Sierra Nevada for Sub-Watershed Scale Adaptation to Climate Change. Journal of American Water Resources Association 45:1409-1423.

Yuan, Z-Y., W-W. Zhou, X. Chen, N.A. Poyarkov, Jr., H-M. Chen, N-H. Jang-Liaw, W-H. Chou, N.J. Matzke, K. Iizuka, M-S. Min, S.L. Kuzmin, Y-P. Zhang, D.C. Cannatella, D.M. Hillis, and J. Che. 2016. Spatiotemporal Diversification of the True Frogs (Genus *Rana*): A Historical Framework for a Widely Studied Group of Model Organisms. Systematic Biology 65(5):824–842. DOI: 10.1093/sysbio/syw055

Zhang, H., C. Cai, W. Fang, J. Wang, Y. Zhang, J. Liu, and X. Jia. 2013. Oxidative Damage and Apoptosis Induced by Microcystin-LR in the Liver of *Rana nigromaculata* in Vivo. Aquatic Toxicology 140-141:11-18.

Zillioux, E.J., D.B. Porcella, and J.M. Benoit. 1993. Mercury Cycling and Effects in Freshwater Wetland Ecosystems. Environmental Toxicology and Chemistry 12:2245-2264.

Zweifel, R.G. 1955. Ecology, Distribution, and Systematics of Frogs of the *Rana boylei* Group. University of California Publications in Zoology 54(4):207-292.

Zweifel, R.G. 1968. *Rana boylii* Baird, Foothill Yellow-legged Frog. Catalogue of American Amphibians and Reptiles. Pp. 71.1-71.2.

Personal Communications

Anderson, D. 2017. Redwood National Park. Foothill Yellow-legged Frog (*Rana boylii*) Survey of Redwood Creek on August 28, 2017, Mainstem Redwood Creek, Redwood National Park, Humboldt County, California.

Ashton, D. 2017. U.S. Geological Survey. Email response to Department solicitation for information.

Blanchard, K. 2018. California Department of Fish and Wildlife. Email response to Department solicitation for information.

Bourque, R. 2018. California Department of Fish and Wildlife. Email.

Bourque, R. 2019. California Department of Fish and Wildlife. Internal review comments.

Chinnici, S. 2017. Humboldt Redwood Company. Email response to the Department solicitation for information.

Dillingham, C. 2019. USDA Forest Service. Email to Caltrans and Department about problematic new culverts.

Grefsrud, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Hamm, K. 2017. Green Diamond Resource Company. Email response to the Department solicitation for information.

Kundargi, K., 2014. California Department of Fish and Wildlife. Internal memo.

Kupferberg, S. 2018. UC Berkeley. Spreadsheet of Eel River egg mass survey results.

Kupferberg, S. 2019. UC Berkeley. Peer review comments.

Kupferberg, S., and A. Lind. 2017. UC Berkeley and USDA Forest Service. Draft recommendation for best management practices to the Department's North Central Region.

Kupferberg, S., and R. Peek. 2018. UC Davis and UC Berkeley. Email to the Department.

Kupferberg, S., R. Peek, and A. Catenazzi. 2015. UC Berkeley, UC Davis, and Southern Illinois University Carbondale. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., and M. Power. 2015. UC Berkeley. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., M. van Hattem, and W. Stokes. 2017. UC Berkeley and California Department of Fish and Wildlife. Email about lower flows in the South Fork Eel River and upstream cannabis.

Peek, R. 2019a. UC Davis. Peer review comments.

Peek, R. 2019b. UC Davis. Email to the Department.

Rose, T. 2014. Wildlife Photographer. Photographs of river otters consuming Foothill Yellow-legged Frogs on the Eel River.

Smith, J. 2015. San Jose State University. Frog and Turtle Studies on Upper Coyote Creek for (2010-2015; cumulative report).

Smith, J. 2016. San Jose State University. Upper Coyote Creek Stream Survey Report – 20 April 2016.

Smith, J. 2017. San Jose State University. Upper Llagas Creek Fish Resources in Response to the Recent Drought, Fire, and Extreme Wet Winter, 8 October 2017.

Sweet, S. 2017. University of California Santa Barbara. Email to the Department.

van Hattem, M. 2018. California Department of Fish and Wildlife. Telephone call.

van Hattem, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Weiss, K. 2018. California Department of Fish and Wildlife. Email.

GIS Data Sources

Amphibian and Reptile Species of Special Concern [ARSSC]. 2012. Museum Dataset.

Biological Information Observation System [BIOS]. Aquatic Organisms [ds193]; Aquatic Ecotoxicology - Whiskeytown NRA 2002-2003 [ds199]; North American Herpetological Education and Research Project (HERP) - Gov [ds1127]; and Electric Power Plants - California Energy Commission [ds2650].

California Department of Fish and Wildlife [CDFW]. Various Unpublished Foothill Yellow-legged Frog Observations from 2009 through 2018.

California Department of Food and Agriculture [CDFA]. Temporary Licenses Issued for Commercial Cannabis Cultivation, January 2019 version.

California Department of Forestry [CAL FIRE]. 2017 Fire Perimeters and 2018 Supplement.

California Department of Water Resources [DWR]. Dams under the Jurisdiction of the Division of Safety and Dams, 2000 version.

California Department of Water Resources [DWR]. Major Canals of California, 2009 version.

California Military Department [CMD]. Camp Roberts Boundary.

California Natural Diversity Database [CNDDB]. August 2019 version.

California Protected Areas Database [CPAD]. Public Lands, 2017 version.

California Wildlife Habitat Relationships [CWHR]. 2014 Range Map Modified in 2019 to Include the Sutter Buttes.

Electronic Water Rights Information Management System [eWRIMS]. Points of Diversion - State Water Resources Control Board, 2019 version.

Facility Registry Service [FRS]. Power Plants Operated by the Army Corps of Engineers – U.S. Environmental Protection Agency Facility Registry Service, 2014 version.

Humboldt Redwood Company [HRC]. Incidental Foothill Yellow-legged Frog Observations from 1995 to 2018.

Mendocino Redwood Company [MRC]. Foothill Yellow-legged Frog Egg Mass Survey Results from 2017 and 2018.

National Hydrography Dataset [NHD]. National Watershed Boundary Dataset, 2016 version.

PRISM Climate Group [PRISM]. Annual Average Precipitation for 2012 through 2016; and the 30 Year Average from 1980-2010.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

U.S. Bureau of Land Management [BLM]. Tribal Lands - Bureau of Indian Affairs Surface Management, 2014 version.

U.S. Department of Defense [DOD]. Military Lands Boundaries in California.

APPENDIX A

Acronyms and Abbreviations

Acronym/ Abbreviation	*Definition*
ac	acre
ACOE	United States Army Corps of Engineers
AHCP	Aquatic Habitat Conservation Plan
Bd	*Batrachochytrium dendrobatidis*
BLM	United States Bureau of Land Management
CDFA	California Department of Food and Agriculture
CE	Common Era
CEQA	California Environmental Quality Act
CNDDB	California Natural Diversity Database
CPAD	California Protected Areas Database
CSVRA	Carnegie State Vehicular Recreation Area
CWA	Clean Water Act
DNA	deoxyribonucleic acid
DWR	California Department of Water Resources
ECCC	East Contra Costa County
ERC	Ecological Resources Committee
ESA	Endangered Species Act
F	Fahrenheit
FERC	Federal Energy Regulatory Commission
ft	foot
GIS	Geographic Information System
HCP	Habitat Conservation Plan
hr	hour
HRC	Humboldt Redwood Company
Hz	Hertz
ITP	Incidental Take Permit
lb	pound
LC	lethal concentration
mi	mile
MRC	Mendocino Redwood Company

NCCP	Natural Communities Conservation Plan
NEPA	National Environmental Policy Act
OHV	Off-Highway Vehicle
PLSS	Public Land Survey System
ppm	parts per million
PVA	Population Viability Analysis
RADSeq	Restriction-site Associated DNA Sequencing
RMZ	Riparian Management Zone
s	second
SCVHP	Santa Clara Valley Habitat Plan
SJMSCP	San Joaquin County Multi-Species Habitat Conservation and Open Space Plan
SSC	Species of Special Concern
SUL	snout-to-urostyle length
SWRCB	State Water Resources Control Board
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WQC	Water Quality Certification
WUI	wildland-urban interface
WSRA	Wild and Scenic Rivers Act
yr	year

APPENDIX B

Metric Unit Conversions

Standard Unit	*Conversion to Metric Units*
acre	1 acre = 0.4047 hectare
acre-foot	1 acre-foot = 1,233.48 cubic meters
Fahrenheit	(°F – 32) x 5/9 = °Celsius
foot	1 foot = 0.3048 meter
inch	1 inch = 2.54 centimeters; 1 in = 25.4 millimeters
pound/acre	1 pound/acre = 1.12 kilograms/hectare
mile	1 mile = 1.6093 kilometers
parts per million	1 part per million = 1 microgram/gram

APPENDIX C

Solicitations for Information

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Wildlife Branch
1812 9th Street
Sacramento, CA 95811
www.wildlife.ca.gov

EDMUND G. BROWN, Jr., Governor
CHARLTON H. BONHAM, Director

July 24, 2017

SUBJECT: NOTIFICATION OF STATUS REVIEW FOR FOOTHILL YELLOW-LEGGED FROG

To whom it may concern:

The California Department of Fish and Wildlife (Department) has initiated a status review of the Foothill Yellow-legged Frog (*Rana boylii*) pursuant to Fish and Game Code section 2074.6 and is providing this notice pursuant to Fish and Game Code section 2074.4 to solicit data and comments on the petitioned action from interested and affected parties.

The Department has initiated this status review following the Fish and Game Commission's (Commission) decision to accept for consideration the petition to list the species under the California Endangered Species Act (CESA) at its June 21, 2017 meeting. Having provided public notice (Cal. Reg. Notice Reg. 2017, No. 27-Z, pp. 986-987; Fish & G. Code, § 2074.2), the Foothill Yellow-legged Frog is now a candidate species under CESA. As a candidate species, the Foothill Yellow-legged Frog receives the same legal protection afforded to an endangered or threatened species (Fish & G. Code, § 2085).

The Department has 12 months to review the petition, evaluate the available information, and report back to the Commission whether or not the petitioned action is warranted. (Fish & G. Code, § 2074.6.) The Department's recommendation must be based on the best scientific information available to the Department. (Fish & G. Code, § 2074.6.)

Anyone with data or comments on the Foothill Yellow-legged Frog's ecology, genetics, life history, distribution, abundance, habitat, the degree and immediacy of threats to reproduction or survival, adequacy of existing management, and recommendations for management of the species, is hereby requested to provide such data or comments to:

California Department of Fish and Wildlife
Attn: Laura Patterson
1812 9th Street
Sacramento, California 95811
wildlifemgt@wildlife.ca.gov

Please submit two hard copies if submitting by surface mail. If submitting by email, please include "Foothill Yellow-legged Frog" in the subject heading.

Responses and information received by **August 31, 2017,** will be evaluated for incorporation in the Department's final report to the Commission. The Department's written report will indicate, based on the best scientific information available, whether the Department concludes that the petitioned action is warranted or not warranted. Receipt of the report will be placed on the agenda for the next available meeting of the Commission after delivery. The report will be made available to the public at that time. Following receipt of the Department's report, the Commission will allow a 30-day public comment period prior to taking any action on the Department's recommendation.

As a candidate species, the Foothill Yellow-legged Frog receives the same legal protection afforded to an endangered or threatened species under the California Endangered Species Act (Fish & G. Code, § 2085). Research on Foothill Yellow-legged Frog requires appropriate permits issued pursuant to Fish and Game Code Section 2081(a). Detection information on Foothill Yellow-legged Frogs should be sent to the California Natural Diversity Data Base at https://www.wildlife.ca.gov/Data/CNDDB/Submitting-Data.

Interested researchers or anyone with questions may contact Laura Patterson at 916-341-6981 or at the email or address above

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Wildlife Branch
1812 9th Street
Sacramento, CA 95811
www.wildlife.ca.gov

EDMUND G. BROWN, Jr., Governor
CHARLTON H. BONHAM, Director

July 24, 2017

Honorable [Name]
[Title]
[Tribe name]
[Address]

SUBJECT: NOTIFICATION OF STATUS REVIEW FOR FOOTHILL YELLOW-LEGGED FROG

Dear Honorable Tribal Representative:

The California Department of Fish and Wildlife (Department) has initiated a status review of the Foothill Yellow-legged Frog (*Rana boylii*) pursuant to Fish and Game Code section 2074.6 and is providing this notice pursuant to Fish and Game Code section 2074.4 to solicit data and comments on the petitioned action from interested and affected Tribes. The Department has initiated this status review following the Fish and Game Commission's (Commission) decision to accept for consideration the petition to list the species under the California Endangered Species Act (CESA) at its June 21, 2017 meeting. Having provided public notice (Cal. Reg. Notice Reg. 2017, No. 27-Z, pp. 986-987; Fish & G. Code, § 2074.2), the Foothill Yellow-legged Frog is now a candidate species under CESA. As a candidate species, the Foothill Yellow-legged Frog receives the same legal protection afforded to an endangered or threatened species (Fish & G. Code, § 2085).

The Department has 12 months to review the petition, evaluate the available information, and report back to the Commission whether or not the petitioned action is warranted (Fish & G. Code, § 2074.6). The Department's recommendation must be based on the best scientific information available. The Department would welcome your Tribe to provide any data or comments on the species' ecology, genetics, life history, distribution, abundance, habitat, the degree and immediacy of threats to its reproduction or survival, the adequacy of existing management, and recommendations for management of the species.

Please provide such data or comments to "Attn: Laura Patterson" at the address in the letterhead. Please provide two hard copies if submitting by surface mail. Comments may also be sent via email to: wildlifemgt@wildlife.ca.gov. If submitting by email, please include "Foothill Yellow-legged Frog" in the subject heading. Please submit Foothill Yellow-legged Frog detection information to the California Natural Diversity Database at: https://www.wildlife.ca.gov/Data/CNDDB/Submitting-Data.

The Department respectfully requests your Tribe provide any responses and information before **August 31, 2017** to allow sufficient time to evaluate the information for possible incorporation in the Department's final status review report to the Commission. The written report will indicate, based on the best scientific information available, whether the Department concludes that the petitioned action is warranted or not warranted. Receipt of the status review report will be placed on the agenda for the next available Commission meeting after delivery. The report will be made available to the public at that time. Following receipt of the Department's report, the Commission will allow a 30-day public comment period prior to taking any action on the Department's recommendation.

The Department welcomes direct communication and consultation to discuss the status review of Foothill Yellow-legged Frog and to identify any impacts to Tribal interests or cultural resources. The Department is committed to open communication with your Tribe under its Tribal Communication and Consultation Policy, which is available through the Department's Tribal Affairs webpage at https://www.wildlife.ca.gov/General-Counsel/Tribal-Affairs.

If you would like more information on the Foothill Yellow-legged Frog status review, please contact Laura Patterson at 916-341-6981 or the Department via email at wildlifemgt@wildlife.ca.gov or at the address above. To request formal government-to-government consultation pursuant to the Department's Tribal Communication and Consultation Policy, please respond in writing to Tribal Liaison Nathan Voegeli by email tribal.liaison@wildlife.ca.gov or by mail to Department of Fish and Wildlife, 1416 9th Street, Suite 1341, Sacramento, CA 95814. Please designate and provide contact information for the appropriate Tribal lead person.

We look forward to your response and input on the Foothill Yellow-legged Frog status review.

Sincerely,

Kari Lewis, Acting Chief
Wildlife Branch

ec: California Department of Fish and Wildlife

Stafford Lehr, stafford.lehr@wildlife.ca.gov
Deputy Director, Wildlife and Fisheries Division

Nathan Voegeli, tribal.liaison@wildlife.ca.gov
Tribal Liaison, Office of the General Counsel

Scott Gardner, scott.gardner@wildlife.ca.gov
Acting Nongame Wildlife Program Manager, Wildlife Branch

Laura Patterson, laura.patterson@wildlife.ca.gov
Senior Environmental Scientist (Specialist), Wildlife Branch

California Endangered Species Act, Endangered Species, Public Participation

CDFW Seeks Information Related to Foothill Yellow-legged Frog

July 21, 2017

The California Department of Fish and Wildlife (CDFW) is seeking information relevant to a proposal to list the Foothill Yellow-legged Frog as a threatened species.

The Foothill Yellow-legged Frog (*Rana boylii*) inhabits lower elevation creeks, streams and rivers throughout the Klamath, Coast, Sierra Nevada and formerly the Transverse ranges of California. They can be found in a variety of habitat types such as chaparral, oak woodland, mixed coniferous forest, riparian sycamore and cottonwood forest, as well as wet meadows.

In December 2016, the Center for Biological Diversity submitted a petition to the California Fish and Game Commission to formally list the Foothill Yellow-legged Frog as threatened under the California Endangered Species Act. The listing petition described a variety of threats to the survival of Foothill Yellow-legged Frogs in California. These include direct and indirect impacts associated with dams, water diversions and development, invasive species, disease, climate change and other activities such as marijuana cultivation, timber harvest, mining, recreation, road building and urbanization. The Commission followed CDFW's recommendation and voted to advance the species to candidacy on June 21, 2017. The Commission published findings of this decision on July 7, 2017, triggering a 12-month period during which CDFW will conduct a status review to inform the Commission's decision on whether to list the species.

As part of the status review process, CDFW is soliciting information from the public regarding the Foothill Yellow-legged Frog's ecology, genetics, life history, distribution, abundance, habitat, the degree and immediacy of threats to reproduction or survival, adequacy of existing management and recommendations for management of the species. Comments, data and other information can be submitted in writing to:

California Department of Fish and Wildlife
Attn: Laura Patterson
1812 Ninth St.
Sacramento, CA 95811

Comments may also be submitted by email to wildlifemgt@wildlife.ca.gov. If submitting comments by email, please include "Foothill Yellow-legged Frog" in the subject heading.

All comments received by **Aug. 31, 2017** will be evaluated prior to submission of the CDFW report to the Commission. Receipt of the report will be placed on the agenda for the next available meeting of the Commission after delivery and the report will be made available to the public at that time. Following the receipt of the CDFW report, the Commission will allow a 30-day public comment period prior to taking any action on CDFW's recommendation.

The Center for Biological Diversity's listing petition and CDFW's petition evaluation for the Foothill Yellow-legged Frog are available at www.fgc.ca.gov/CESA/index.aspx#fylf.

# # #

Media Contacts:
Laura Patterson, CDFW Wildlife Branch, (916) 341-6981
Kyle Orr, CDFW Communications, (916) 322-8958

APPENDIX D

Public and Tribal Comments

Note: The attached comments were received during the public solicitation for information period plus one week. The reports and papers provided are not included due to their excessive size, and copyrights in some cases, but are available upon request.

Patterson, Laura@Wildlife

From: Trent Saxton
Sent: Friday, July 21, 2017 7:24 PM
To: Wildlife Management
Subject: Your Yellow Frog search is a joke and you know it...here is the real reason

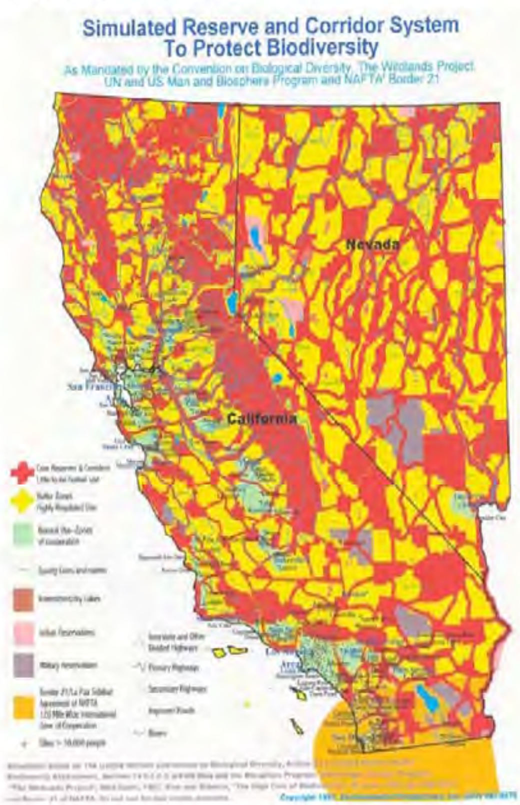
LIVE, WORK OR RECREATE IN THE RED ZONE—START PACKING THE FROG IS MOVING IN!

PROOF FISH AND WILDLIFE ENDANGERED FROG IS A FRAUD!

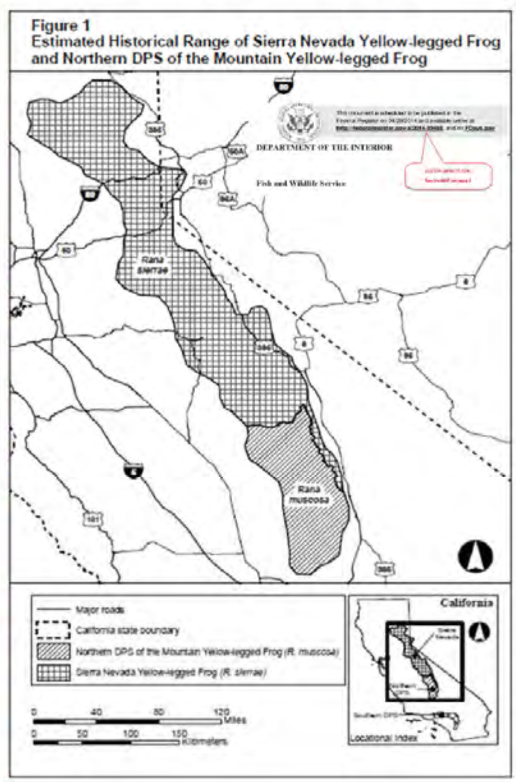
COMPARE WILDLANDS PROJECT MAP, WITH LEGEND FOR RED—LITTLE TO NO HUMAN USE, And THE "ESTIMATED HISTORICAL RANGE OF Sierra Nevada Yellow Legged Frog provided in the

1.1. Background—On January 27, 2010, the Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity (Center) to list all populations of Mountain Yellow Legged Frog (MYLF) as "Endangered" under California Endangered Species Act (CESA). (A Status Review of the Mountain Yellow-Legged Frog, pg. 1)

Source of Map below:
http://discerningtoday.org/



Source of Map below:
http://federalregister.gov/a/2014-09488 at pg. 8



PROOF OF A HIDDEN AGENDA BEHIND, THE CALIFORNIA FISH & WILDLIFE ENGANGERED FROG HOAX.

These two maps were created approximately twenty years apart, by entirely different entities, yet the area identified for the "endangered frog is almost an exact overlay of the large area in Red designated for "Little to No Human Use" in the UN NAFTA Wildlands Project!

Patterson, Laura@Wildlife

From: Sinnen, Wade@Wildlife
Sent: Friday, July 21, 2017 10:14 AM
To: Patterson, Laura@Wildlife
Subject: RE: CDFW Seeks Information Related to Foothill Yellow-legged Frog

Hi Laura,

I'm not sure who may compiling information for this petition but wanted to point out there are several reports on the species that can be obtained from the following Trinity River restoration Program web portal:

http://odp.trrp.net/Search/Search.aspx

Regards,

Wade

Wade Sinnen
Senior Environmental Scientist (supervisor)
CA Department of Fish and Wildlife
5341 Ericson Way
Arcata, CA 95521

From: Wildlife CDFWNews
Sent: Friday, July 21, 2017 9:38 AM
To: Wildlife CDFW_ALL <CDFW_All@wildlife.ca.gov>
Subject: CDFW Seeks Information Related to Foothill Yellow-legged Frog

This draft news release is being sent to all CDFW employees. It is not yet public. Please do not distribute. If you have any concerns, please contact the individual(s) listed at the top of the release (do not reply to this email). When it is made public, it will be posted at www.wildlife.ca.gov/news.

California Department of Fish and Wildlife News Release

July 21, 2017

Media Contacts:
Laura Patterson, CDFW Wildlife Branch, (916) 341-6981
Kyle Orr, CDFW Communications, (916) 322-8958

CDFW Seeks Information Related to Foothill Yellow-legged Frog

The California Department of Fish and Wildlife (CDFW) is seeking information relevant to a proposal to list the Foothill Yellow-legged Frog as a threatened species.

The Foothill Yellow-legged Frog (*Rana boylii*) inhabits lower elevation creeks, streams and rivers throughout the Klamath, Coast, Sierra Nevada and formerly the Transverse ranges of California. They can be found in a variety of habitat types such as chaparral, oak woodland, mixed coniferous forest, riparian sycamore and cottonwood forest, as well as wet meadows.

In December 2016, the Center for Biological Diversity submitted a petition to the California Fish and Game Commission to formally list the Foothill Yellow-legged Frog as threatened under the California Endangered Species Act. The listing petition described a variety of threats to the survival of Foothill Yellow-legged Frogs in California. These include direct and indirect impacts associated with dams, water diversions and development, invasive species, disease, climate change and other activities such as marijuana cultivation, timber harvest, mining, recreation, road building and urbanization. The Commission followed CDFW's recommendation and voted to advance the species to candidacy on June 21, 2017. The Commission published findings of this decision on July 7, 2017, triggering a 12-month period during which CDFW will conduct a status review to inform the Commission's decision on whether to list the species.

As part of the status review process, CDFW is soliciting information from the public regarding the Foothill Yellow-legged Frog's ecology, genetics, life history, distribution, abundance, habitat, the degree and immediacy of threats to reproduction or survival, adequacy of existing management and recommendations for management of the species. Comments, data and other information can be submitted in writing to:

California Department of Fish and Wildlife
Attn: Laura Patterson
1812 Ninth St.
Sacramento, CA 95811

Comments may also be submitted by email to wildlifemgt@wildlife.ca.gov. If submitting comments by email, please include "Foothill Yellow-legged Frog" in the subject heading.

All comments received by **Aug. 31, 2017** will be evaluated prior to submission of the CDFW report to the Commission. Receipt of the report will be placed on the agenda for the next available meeting of the Commission after delivery and the report will be made available to the public at that time. Following the receipt of the CDFW report, the Commission will allow a 30-day public comment period prior to taking any action on CDFW's recommendation.

The Center for Biological Diversity's listing petition and CDFW's petition evaluation for the Foothill Yellow-legged Frog are available at www.fgc.ca.gov/CESA/index.aspx#fylf.

Patterson, Laura@Wildlife

From: Eric Olson
Sent: Friday, July 21, 2017 2:52 PM
To: Patterson, Laura@Wildlife
Subject: Foothill Yellow-legged Frog

Laura,
I saw the TWS post on facebook about the call for information on Foothill Yellow-legged Frog. I'm not sure that I have much to add, but when I did my master's work in the Sutter Buttes I searched the creeks within the State Park for the species but never found them. I also confirmed the ID of the one specimen that is at Chico State from the Buttes.

My personal opinion is that if a FYLF population was present at the Sutter Buttes, the feral pigs have probably wiped them all out. All of the creeks I encountered during the summer were reduced to small pools,and those pools almost always were turned into pig wallows. That, along with other researchers not being recording the species other than the one specimen leads me to believe that they have been extirpated from the Buttes.

Anyway, that's probably all old news for you, but just in case it was useful I thought I would let you know.

Thanks and good luck!
Eric

--
Eric Olson
Northern California Preserve Manager
Center for Natural Lands Management

Patterson, Laura@Wildlife

From: Rosalind Helfand
Sent: Saturday, July 22, 2017 1:17 PM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog - Attn Laura Patterson

Dear Ms. Patterson,

Hello. I'm submitting observations on Foothill Yellow-legged Frog habitat.

On October 7, 2016 at around 4pm, my husband and I observed and photographed three Foothill Yellow-legged Frogs in a shallow stream with clear water moving moderately fast feeding into the Smith River. This was not far from Stout Grove in Jedediah Smith Redwoods State Park.

The environment was very cool (although it was a very warm day in the sun) with dense trees and foliage and fully shaded at the time. The frogs both sat on rocks in the stream and hid in the water under tree debris (mostly bits of redwood tree) lining the sides of the stream.

The stream ran under a pedestrian bridge for a fairly heavily used trail and the frogs were found close to the bridge location -- both down and upstream.

It's clear that the habitat is fragile. If the stream were to dry up or be blocked or polluted, or if people were to walk in and around it regularly, it appears it would be a threat to the frogs.

We're happy to submit our photographs if desired.

Thank you!

Rosalind Helfand and Steven Calcote

--
Rosalind Helfand
Advisor/Director/Programming Developer, Nonprofits & Government

Patterson, Laura@Wildlife

From: Alan Peterson
Sent: Saturday, July 22, 2017 2:17 PM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog
Attachments: Foothill-Yellow-Legged-Frog.jpg

Sorry, the attachment didn't make it onto the last email. Here it is again:

In response to the request for information about the foothill yellow-legged frog, they can be found around the tributaries to the Mad River near Blue Lake, California. I photographed this one next to Boundary Creek during April of this year.

Patterson, Laura@Wildlife

From: jimkatta
Sent: Sunday, July 23, 2017 9:14 AM
To: Wildlife Management
Subject: Foothill Yellow Frog

I have been a California Fisherman for 45yrs. I have bought California Fishing licenses for 39yrs. I remember the good old days of fishing the San Gabriel River, Piru Creek, Cucamonga Creek and the Arroyo Seco Creek. So Cal trout fishing was good back in those days. That stupid frog ruined it, more people trout fish than watch that frog. That was a typical California maneuver wrecking something that was good for a bunch of the citizens to make a few people happy. I say lift the ban and start stocking the creeks again!

Sent from Mail for Windows 10

Patterson, Laura@Wildlife

From: Holly Dalton
Sent: Monday, July 24, 2017 12:33 AM
To: Wildlife Management

I , amfrom Northern California. I read the article on the frogs, I have also noticed most anfibian species are disappearing... (banana slugs, snails, a lot of turtles and snakes..) as well as most incects..and ..fish....where are surf fish..?

Patterson, Laura@Wildlife

From: larry kellerhals
Sent: Monday, July 24, 2017 2:26 PM
To: Wildlife Management
Subject: Foothill yellow legged frog

Man does not effect 1% of the total forest acreage. Locking man out will not change a thing as far as endangered species are concerned.
Larry Kellerhals

Sent from my Verizon 4G LTE Droid

Patterson, Laura@Wildlife

From: David Ingraham
Sent: Tuesday, July 25, 2017 12:24 AM
To: Wildlife Management
Subject: The possible listing of the Yellow legged frog as recommended by certain environmental groups

I must object to this listing of the yellow legged frog as endangered. Poor management of the perpetuation of the species is the problem and should be the recourse to improve numbers of the species. It has all ways been the California fish and game duty to help species survive, by devoting high intensity farming of the species at either hatcheries, or game farms. Then reintroducing the species back into the wild. I recommend using some of the game reserves to set up small eco-habitat, such as an open fenced terrarium of the perfect environment to provide advantages for the species to survive. The environmentalist are trying to destroy the right of the people to harvest the natural resources of public land to advance their communist agenda of government control over our lands. That The Fish and Wild life would be in collusion to their agenda of enemies of the rights of the people and traitors to the United States of America.
Proper management of out public lands require harvesting and fire breaks This designation would stop good land management of public lands. Creating an endangered species is the way environmentalists have created conditions of bad forest management , by creating a much more dangerous environment for all.

David J. Ingraham

Patterson, Laura@Wildlife

From: Ray & Diane
Sent: Wednesday, July 26, 2017 8:59 AM
To: Wildlife Management
Subject: Foothill Yellow Legged Frog

I presume this is a different frog than used as justification to remove fish from several of the lakes I have fished for over 65 years in the Desolation Valley Wilderness. Another lake (Island) is on the hit list for this year even tho fish are not the problem as scientifically proven. Please replant all these lakes and vacate this failed science.

Ray Melson
Sent from my iPad

Patterson, Laura@Wildlife

From: Clayton Strahan
Sent: Wednesday, July 26, 2017 9:57 AM
To: Wildlife Management
Subject: Yellow legged Frog

Dear Mrs. Patterson
I'd like to take a moment express my sincere concerns associated with the potential listing of the yellow legged frog. I have been employed as a peak ranger for more than a decade and deal daily with the many challenges associated with the rapidly increasing environmental regulations resulting from ESA listings such as the arroyo toad, the least turns vario and the SoCal steelhead. Additionally as and avid outdoorsmen, hunter and conservationists I have watched as rampant environmental regulations have reduced, limited and or all together taken away opportunity and access from the public. With that said I also recognize that ESA protections are important and am supportive of reasonable and practical regulations aimed at protecting endangered or threatened species.

However, in this case I am very concerned that this listing is nothing more than a veiled attack by the center for biological diversity to further limit recreational opportunities and to forward the environmental agenda of a small but powerful group of the states population. I challenge the commission to finally take a long hard look at the number of lawsuits filed by the center for biological diversity and to consider the fact that this organization along with 2 others has crippled the state and its residents with bogus environmental requests and lawsuits in an effort to advance their agenda. At what point will the commission take an actual hard look and start considering the balance of humans versus environmental regulation. As noted, I am supportive of reasonable regulation, but at this point in time I cannot support the listing of another species that i believe will only further limit my access to public lands because of the threats of organizations like center for biological diversity. I chsllenge the commission and other regulatory organizations to have a backbone. The ESA was intended to protect endangered species and to provide balance between and angered species and humans, and instead the pendulum has swung out of control because of the fear of litigation. I assure you the majority of tax layers would gladly spend money fight fight such aggeegious threats and claims and would rather do so then to have unreasonableand costly regulations placed on them.

I ask the commission that if they do take steps to list this species, that they do so with sound science and with a backbone. I hope that the commission takes the opportunity to make it clear to organizations like the center for biological diversity that they will not be influenced or controlled by the threat of litigation and that if listed regulations imposed will be based on balance between man and wildlife and that they will end this wildlife first attitude they have had in the past.

Sincerely
Clayton Strahan
Resident of Tehachapi, Ca

Patterson, Laura@Wildlife

From: gregbosworth
Sent: Wednesday, July 26, 2017 12:21 PM
To: Wildlife Management
Subject: foothill yellow legged frog

This frog, and the enviro Nazi's of this state are ruining rural mountain economies!!! No fish planting in the rivers and streams means no tourists, no tourists mean no money for local business. What are WE supposed to do??? Are mountain economies to go extinct themselves, over this reptile??? NO MORE ENVIRO FACISM!!!!! PEOPLE NOT FROGS!!!! Theres nothing hard about it!

Patterson, Laura@Wildlife

From: Terry Peterson
Sent: Thursday, July 27, 2017 1:26 AM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog

This is by far the dumbest thing in years. The impact economically and to the general health of people that rely on those streams and waterways far outweighs the damn frog. This is stupid.

Terry Peterson

Patterson, Laura@Wildlife

From: Phillip Reyes
Sent: Thursday, July 27, 2017 5:40 AM
To: Wildlife Management
Subject: Foothill yellow legged frog

Since the ban on dredging I have only seen a decline in fish and wildlife populations AND a decrease in prosperity and population in these northern California communities. If we're really worried about the environment, how about not tunneling water to so. cal. for a start? How about leaving alone the folks who have lived off of and have taken good care of the lands up here in no. Cal? Why are "we" pretending to care about the environment and simultaneously publicly funding environmentally and economically destructive policies, programs and projects??? It's Naziism and it's affecting PEOPLE who are much more important to me than a yellow legged frog that has not been impacted at all by people carying on their business as they always have up here. Leave us alone and stop further restricting access to and use of OUR land.

Patterson, Laura@Wildlife

From: Steve Regis
Sent: Tuesday, August 1, 2017 6:59 PM
To: Wildlife Management
Subject: Yellow Legged Foothill Frog

This frog is classified near-threatened. If DFW lists it, all inland fishing in California will be destroyed. DFW barely analyzed the wild and misleading claims of the Center for Biodiversity since they were pre-disposed in favor of anything to block fishing and hunting and public use of lands.

Patterson, Laura@Wildlife

From: Welsh, Hartwell - FS
Sent: Wednesday, August 9, 2017 4:21 PM
To: Patterson, Laura@Wildlife
Subject: Rana boylii information request
Attachments: RABO initiation ms 071217akc.doc; Figures 28Mar17.pptx

Hi Laura:
Attached is a manuscript that is currently in review with the Journal of Herpetology. Please treat this information as unpublished research (until we have it accepted for publication). I hope it proves useful during your review process.
Best,
Hart

Hartwell H. Welsh, Ph.D.
Research Wildlife Biologist - Emeritus
Conservation of Biodiversity
Forest Service
Pacific Southwest Research Station

Caring for the land and serving people

Patterson, Laura@Wildlife

From: Voegeli, Nathan@Wildlife
Sent: Thursday, August 10, 2017 8:13 AM
To: Patterson, Laura@Wildlife
Subject: FW: Foothill Yellow-Legged Frog

fyi

--
Nathan Voegeli
Attorney, Office of the General Counsel
California Department of Fish and Wildlife
916-651-7653

From: THPO@gratonrancheria.com [
Sent: Wednesday, August 09, 2017 4:52 PM
To: Voegeli, Nathan@Wildlife <Nathan.Voegeli@wildlife.ca.gov>
Subject: Foothill Yellow-Legged Frog

Dear Nathan Voegeli,

The Tribe has received the project notification letter dated July 24, 2017, requesting interest and input regarding the Foothill Yellow-Legged Frog. We appreciate your effort to contact the Tribe. The Tribal Heritage Preservation Office staff has reviewed the project information. Based on the project details, the Tribe does not have any comments to provide at this time. Should the project be modified the Tribe respectfully requests project notification and the opportunity to review the project. Thank you for contacting the Tribe with this notice and the opportunity to provide comment.

Sincerely,
Buffy McQuillen
Tribal Heritage Preservation Officer (THPO)
Native American Graves Protection and Repatriation Act (NAGPRA)

Antonette Tomic
THPO Administrative Assistant
Federated Indians of Graton Rancheria

Patterson, Laura@Wildlife

From: Cedric Twight
Sent: Thursday, August 10, 2017 12:34 PM
To: Patterson, Laura@Wildlife
Subject: NOAA CA Central Valley Salmon Recovery Coordinator
Attachments: Brian Ellrott.vcf

Hello Laura,

The person that is coordinating the placement of listed salmon above dams in the Central Valley is Brian Elliott. It is my understanding that NOAA has had studies completed on several rivers above dams where they think reintroductions may be successful. Those studies may have relatively current FYLF information in them. Brian may be able to expedite you receiving that information. Good Luck.

-
-
- **Brian Ellrott**
  NOAA
  California Central Valley Recovery Co...

Cedric Twight
Manager of California Regulatory Affairs
Sierra Pacific Industries

SIERRA PACIFIC INDUSTRIES

Patterson, Laura@Wildlife

From: Friends of Tesla Park
Sent: Friday, August 11, 2017 1:30 PM
To: Wildlife Management
Cc: Grefsrud, Marcia@Wildlife
Subject: Comments submitted on proposal to list Foothill Yellow-legged Frog (Rana boylii) as Threatened under CESA
Attachments: FYLF boylii letter to CDFW Aug 11 2017.pdf

Dear Ms. Patterson:

Attached are comments submitted for the status review being conducted by the California Department of Fish and Wildlife with regard to the proposal to list Foothill Yellow-legged Frog (*Rana boylii)* as Threatened under California Endangered Species Act. The signers of this letter, which include Save the Frogs, Sierra Club, Ohlone Audubon Society, Save Mount Diablo, Citizens Committee to Complete the Refuge, SPRAWLDEF, and Friends of Tesla Park support listing the Foothill Yellow-legged Frog as Threatened under CESA and designation of the Corral Hollow Creek Watershed as critical habitat.

Thank you.

Nancy Rodrigue

Friends of Tesla Park
www.TeslaPark.org

Friends of Tesla Park is an alliance dedicated to establishing Tesla Park as a non-motorized low impact historical and natural resource park and preserve.

August 11, 2017

SENT VIA US MAIL AND E-MAIL

California Department of Fish and Wildlife
Attn: Laura Patterson
1812 Ninth St.
Sacramento, CA 95811
wildlifemgt@wildlife.ca.gov.

Re: Proposal to list Foothill Yellow-legged Frog (*Rana boylii)* as Threatened under California Endangered Species Act

To Whom It May Concern:

We write in support of the California Fish and Game Commission proposal to list *Rana boylii*, the Foothill yellow-legged frog (FYLF) as a threatened species under the California Endangered Species Act (CESA). The signers of this letter are part of the Friends of Tesla Park alliance, a group of individuals and organizations working to preserve public wildlands in southeastern Alameda County, in an area commonly referred to as the Tesla park land and Corral Hollow Creek watershed.

Public and open space lands are often-times assumed to provide sanctuary for species in decline. This letter demonstrates, using the biologically rich Corral Hollow Creek watershed (Fig. 1) as a case study, that unregulated, or under-regulated, activities on publicly owned lands can have significant, adverse impacts to FYLF, and thus they require protection under CESA. These frogs have long been known to occur in Corral Hollow Creek. Museum records of abundant FYLF populations date back to 1911 and continue through time until the last few decades[1]. The persistence of FYLF has become tenuous because of the destruction and modification of their fluvial habitat due to Off Highway Vehicle (OHV) use at the Carnegie State Vehicular Recreation Area (CSVRA). Proposed expansion of CSVRA into Tesla threatens future

[1] University of California, Berkeley Museum of Vertebrate Zoology. Available url [http://arctos.database.museum/SpecimenSearch.cfm] accessed 8/5/2015.

destruction of habitat that is currently intact. In this letter, we highlight the inadequacy of existing regulatory mechanisms within the California State Parks Off-Highway Motor Vehicle Recreation (OHMVR) Division to protect FYLF. We also highlight the vulnerability of small isolated populations to stochastic events that can lead to extirpation and the implications of climate change for FYLF.

Although we focus on the Corral Hollow Creek watershed, the threat posed by OHV use to this species on publicly owned land is not limited to this one location. Similar OHV related threats occur elsewhere in the range of FYLF including Frank Raines OHV Park (Stanislaus Co. along Del Puerto Creek), Hollister Hills State Vehicular Recreation Area, and the Clear Creek area managed by the Bureau of Land Management (San Benito Co.). There are other publicly owned lands that are not specifically designated for OHV use, but where OHV use is allowed in the watersheds either currently, or historically, occupied by FYLF. Included in this category are the various US National Forests[2] (e.g. in the foothills of the Sierra Nevada). Improved regulatory mechanisms are needed to halt the decline of this species and aid its recovery in the streams and rivers flowing through public lands.

[2] See list of US National Forests with OHV use at http://ohv.parks.ca.gov/?page_id=23140

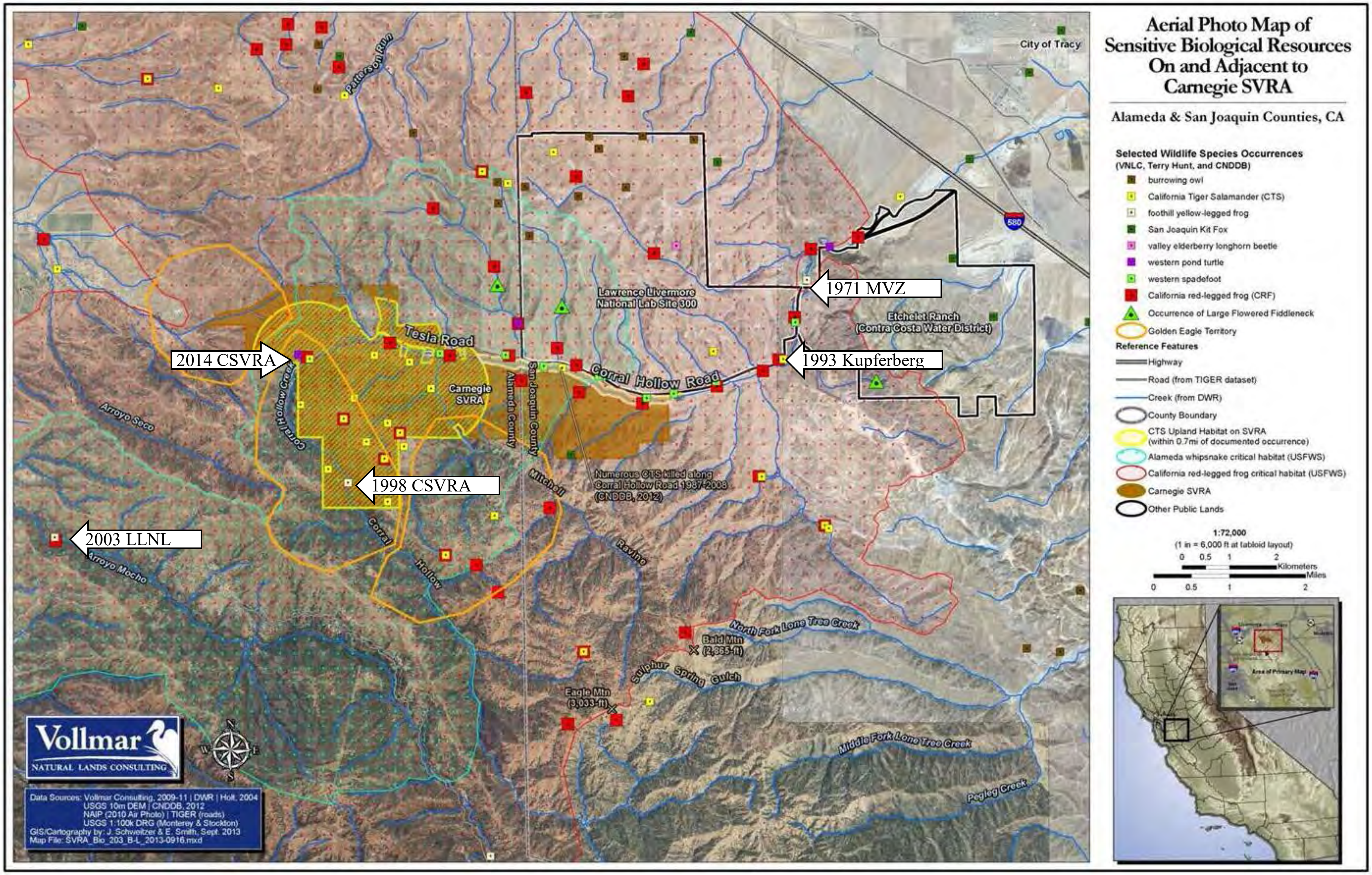


Figure 1 Locations (bold white arrows with years and observers) of Foothill yellow legged frogs observed in the Corral Hollow watershed and vicinity. Observer codes: CSVRA = Carnegie State Vehicular Recreation Area; LLNL = Lawrence Livermore National Laboratory; MVZ = Museum of Vertebrate Zoology at UC Berkeley; Kupferberg = Sarah Kupferberg personal observation/unpublished data.

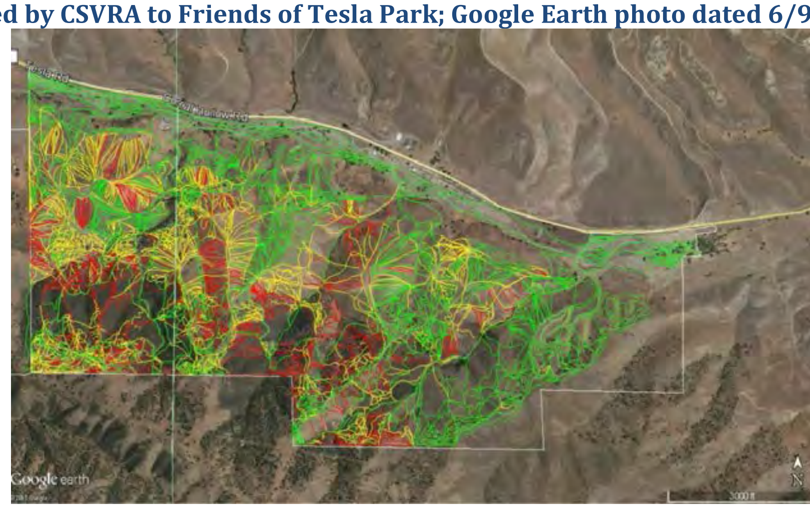
THREATS TO FOOTHILL YELLOW-LEGGED FROGS IN CORRAL HOLLOW

Multiple anthropogenic stressors are contributing to range wide declines of FYLF. Water diversion, extraction, and flow regulation pose major threats, with extirpation having occurred most frequently downstream of large dams[3], but declines have happened in free-flowing streams as well. Heavy erosion and transport of sediment to streams deteriorate conditions, can cause local extirpations[4], and subsequently isolate remaining populations.

1 SEDIMENTATION OF FLUVIAL HABITAT DUE TO OHV INDUCED EROSION

FYLF are now absent from historically occupied reaches of Corral Hollow Creek where OHV use occurs and downstream of the heavily sedimented reach. The stream reach where FYLF still occur is at risk of the same fate if OHV use expands. Twenty years ago, California State Parks purchased land upstream of the existing 1,575-acre CSVRA and is planning a 3,100-acre expansion. The present SVRA hosts at least 0.14 miles of trails per acre (Fig. 2).

Figure 2. Map view of CSVRA OHV trails and erosion status (lines shown as green, yellow, or red). GIS shapefile provided by CSVRA to Friends of Tesla Park; Google Earth photo dated 6/9/2014.



Extrapolation from this estimate of density yields a prediction of at least 447 miles of new OHV trails in the expansion area (*i.e.* 0.14 miles/acre *x* 3100 acres). This linear tally and extrapolation greatly under-represents the amount of de-vegetated area prone to erosion around all trails, not only those designated yellow and red by CSVRA, where severe soil loss occurs (Fig. 3). We believe that CESA protection of a species in the streams receiving the sediment will improve regulation of this detrimental activity.

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[3] Kupferberg, S. J., W. J. Palen, A. J. Lind, S. Bobzien, A. Catenazzi, J. Drennan, and M. E. Power. 2012. Effects of flow regimes altered by dams on survival, population declines, and range-wide losses of California river-breeding frogs. Conservation Biology 26:513–524

[4] Sweet, S. S. 1983. Mechanics of a natural extinction event: *Rana boylii* in southern California." Program of the 26th Annual Meeting of the Society for the Study of Amphibians and Reptiles and 31st Annual Meeting of the Herpetologists League at the University of Utah [August 7-12]. Vol. 93

Figure 3. Map view (left) comparing CSVRA-designated trails (lines) and ratings (red, yellow, green color coding) to area of barren surfaces visible in a background aerial image (6/9/2014 Google Earth); associated hillside-gully erosion (right, location of photograph shown by arrow, 4/1/2015).

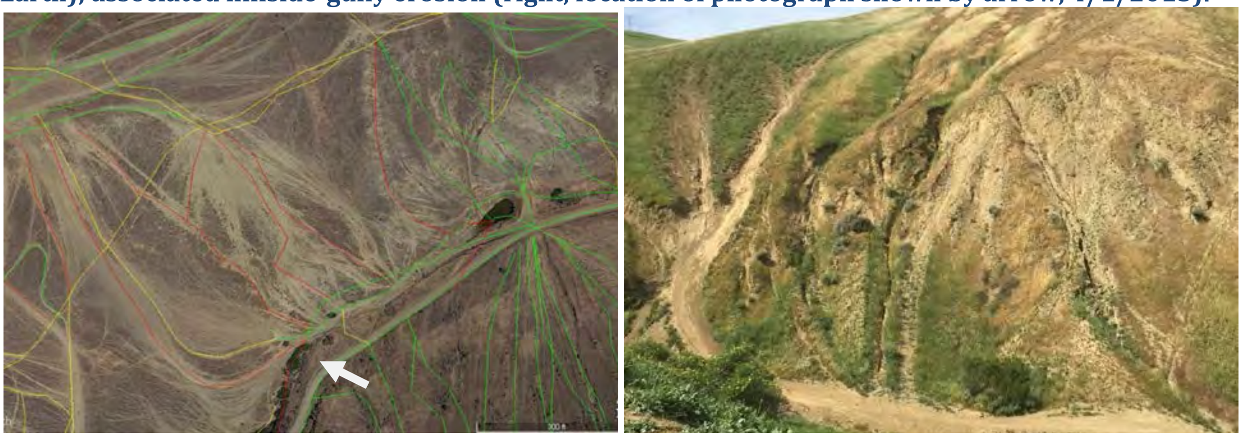

Figure 4. Pervasive hillside runoff concentrated in OHV trails where barren soils become over-saturated and erode in Carnegie SVRA (12/11/2014).

During storms, runoff bearing the fine sediment from the hillsides enters the creeks (Figs. 4, 5). The sediment buries the former stream channel, alters the channel's cross-sectional shape, and decreases the availability of suitable depth, velocity, and substrate habitats preferred by FYLF. These physical habitat features are central requirements for FYLF[5],[6]. As was noted in the Recovery Plan for California red-legged frogs regarding habitat quality in Corral Hollow Creek, "off-road vehicle activities upstream … are decreasing the suitability of the ecological reserve due to high rates of sedimentation during peak stream flows"[7].

Climate change will likely exacerbate the erosion problems. Rainfall patterns are changing from a continuous rainy season that recharges ground water and sustains baseflows to droughts punctuated by intense storms generating maximum runoff and peak streamflows. 'Atmospheric river' storms, such as the one that occurred in December 2014 (Fig. 5), now

[5] Kupferberg, S. J. 1996. Hydrologic and geomorphic factors affecting conservation of the foothill yellow legged frog (*Rana boylii*). Ecological Applications 6:1332–1344.

[6] Yarnell, S. M., A. J. Lind, and J. F. Mount. 2010. Dynamic flow modeling of riverine amphibian habitat with application to regulated flow management. River Research and Applications 28: 177–191.

[7] US Fish and Wildlife Service. 2002. Recovery plan for the California red-legged frog (*Rana aurora draytonii*). *US Fish and Wildlife Service, Portland, OR*.

contribute 80% of Bay Area annual rainfall, compared to 30-50% in the past[8]. Atmospheric rivers are bands of moisture laden air that extend across the Pacific Ocean from the tropics. Some global climate change experts, such as USGS hydrologist Mike Dettinger, predict that "under current climate scenarios, atmospheric rivers will hit Northern California twice as often by 2100 as they do now."[8]

Figure 5. Fine sediment discharge from OHV area to Corral Hollow Creek. (12/11/2014).

2 SMALL POPULATION SIZE AND ISOLATION

FYLF have been sporadically encountered in Corral Hollow Creek in Carnegie SVRA (2014[9], 1998[10], Fig. 1). Both observations were in the proposed CSVRA expansion area, upstream of the current riding area and reaches presently receiving excessively large loads of sediment. The recent sighting was of a single juvenile, which by virtue of its size had metamorphosed the previous summer/fall. This indicates that there is likely a breeding site in the vicinity, yet no appropriately timed and geographically extensive surveys have been conducted to determine the location of the breeding site. Without such information, SVRA expansion plans cannot be modified appropriately. Indeed, specific protection of FYLF was not addressed in the 2016 final EIR approved by CSVRA[11]. As an example of inadequate surveys, TRA Environmental Consultants conducted a survey on Oct. 17, 2013, when the reach was dry. Not surprisingly, no FYLF were detected.

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[8] Rowntree, L. 2015. When it rains, it pours: historic drought and atmospheric rivers. BayNature available url [https://baynature.org/articles/when-it-rains-it-pours/] accessed 8/5/2015.

[9] DeSilva, T. and A. Meisel. 2015. 2011-2014 Habitat Monitoring Systems Report CSVRA.

[10] California Department of Parks and Recreation. 2000. Carnegie State Vehicle Recreation Area General Plan Amendment Environmental Impact Report. Livermore, CA. Prepared by Jones & Stokes. San Jose, CA.

[11] Carnegie State Vehicular Recreation Area. 2016. General Plan Revision, Environmental Impact Report, State Clearinghouse Number 2012052027. Available url accessed 8/10/2017 http://www.carnegiegeneralplan.com/document-library]

FYLF were not historically sparse in Corral Hollow Creek, but their distribution appears to have become fragmented. The 2004 CSVRA Draft Habitat Conservation Plan (p. 6-13)[12], UC Berkeley Museum of Vertebrate Zoology specimens from 1971 (MVZ:Herp:98194), and a survey conducted in 1993 by Dr. Sarah Kupferberg (unpublished data via personal communication) report large numbers of tadpoles downstream of what is now CSVRA. The present rarity of FYLF in Corral Hollow Creek places them at risk of extirpation. A population projection model developed for this species[13] indicates extirpation is extremely sensitive to population size. The likelihood of recolonization after extirpation in Corral Hollow Creek is low because dispersal usually follows watercourses[14] and there are barriers both upstream and downstream of the extant FYLF. Upstream, there is a ridge separating the presently occupied site from the nearest extant population 4 miles away in Arroyo Mocho[15] (Fig. 1). Carnegie SVRA represents the downstream barrier.

3 NEED FOR CESA PROTECTION & IMPLEMENTATION OF CONSERVATION GUIDELINES

California ESA protection of FYLF would improve the implementation of conservation guidelines. The Draft Habitat Conservation Plan from 2004 was never adopted. Presently, the Natural Resource Management Guidelines in CSVRA's General Plan and FEIR approved and certified in October 2016 are insufficient to avoid or minimize impacts on FYLF because the buffer zone along Corral Hollow Creek is too narrow. Furthermore, tributaries are not protected from OHV use and crossings are allowed. Connectivity to seeps and off-channel water bodies is not accounted for. The General Plan and EIR assertion that a 'Limited Recreation Area' (≤ 150 feet on one or the other side of Corral Hollow Creek) would protect FYLF ignores the scientific literature about movement and dispersal in this species. CSVRA also does not consistently establish the 150-foot buffer and limited recreation does not exclude OHV use entirely. It has long been known that juveniles disperse away from natal streams and have been caught up to 600 feet away from a stream channel[16]. FYLF use small tributaries and seeps[17] and move from hundreds to thousands of meters in dendritic stream networks[18]. Development of a recovery plan for FYLF would ground guidelines in science. Further CSVRA is not generally meeting the 150-foot buffer standard within the existing SVRA.

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[12] CSVRA 2004. General Plan Amendment, Draft multiple species Habitat Conservation Plan. prepared by HDR Aug. 2004. Received via Public Records Act Request by Friends of Tesla Park.

[13] Kupferberg, S. J., A. J. Lind, and W. J, Palen. 2009. Pulsed flow effects on the Foothill yellow-legged frog (*Rana boylii*): Population modeling. Final Report. California Energy Commission, PIER. Publication number 500-09-02a. 80 pp. Available url accessed 6/27/2015 [http://www.fs.fed.us/psw/publications/lind/lind(KupferbergCEC-500-2009-xxx).pdf]

[14] Bourque, R. M. 2008. Spatial ecology of an inland population of the Foothill yellow-legged frog (*Rana boylii*) in Tehama County, California. MS Thesis, California State University, Humboldt. 93 pp.

[15] California Natural Diversity Database

[16] Twitty, V., D. Grant, and O. Anderson. 1967. Amphibian orientation: An unexpected observation. Science 155: 352–353.

[17] Gonsolin T. E. 2010. Ecology of foothill yellow-legged frogs in upper Coyote Creek, Santa Clara County, CA. State University of California, San Jose. MS Thesis. 110 pp; Rombough, C. J. 2006. Wintering habitat use by juvenile foothill yellow-legged frogs (*Rana boylii*): the importance of seeps. Northwestern Naturalist 87: 159.

[18] Bourque, R. M. 2008. Spatial ecology of an inland population of the Foothill yellow-legged frog (*Rana boylii*) in Tehama County, California. MS Thesis, California State University, Humboldt.

4 CRITICAL HABITAT AND DISTINCT POPULATION SEGMENT

We believe that Corral Hollow Creek should be designated as critical habitat for FYLF given the location of the watershed within the species' geographic range and the potential for recovery in the publicly owned land if the expansion area can be designated as a preserve with no OHV use. At the latitude of the watershed, 37.6°, Lind[19] estimated that the frogs were missing from more than two thirds of historically occupied sites (Fig. 6). Analysis of mitochondrial DNA data strongly suggests that populations of FYLF at this latitude and further south in the Central California Coast Range constitute a distinct genetic lineage[20]. Samples from the nearby population in Arroyo Mocho were part of Lind et al.'s "Clade D", and we assume Corral Hollow frogs would fall in this lineage.

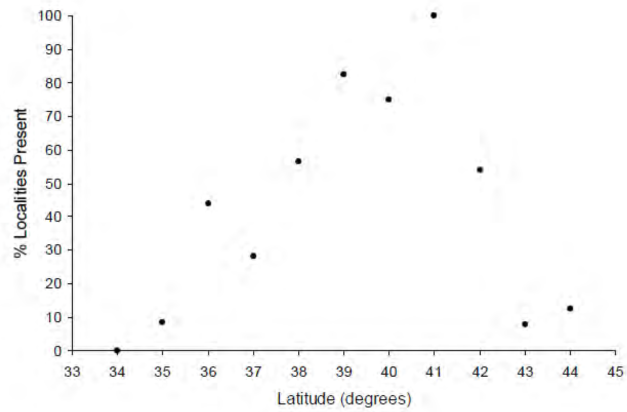

Figure 6. Percent of historic localities with FYLF present in relation to latitude (from Lind 2005).

We urge the California Fish and Game Commission to facilitate research efforts using contemporary nuclear DNA analysis techniques to verify that the Corral Hollow Creek population of FYLF is part of a Distinct Population Segment. Ryan Peek, Ph.D. candidate at UC Davis, is currently working on a project to extend the work of Lind et al.[16] using the same samples which have been maintained in a frozen archive. The most difficult aspect of the project is the logistics of collecting new tissue samples from additional populations of FYLF to fill in geographic sampling gaps. FYLF are often in remote and difficult to access locations. The listing process, status review, and assembly of a working group of scientists and public land managers could provide a unique opportunity to expedite the collection and delivery of tissue samples to Mr. Peek. An accurate assessment of Distinct Population Segments could be produced relatively quickly given a coordinated effort.

An additional geographic reason for designating the Tesla area as Critical Habitat is its location in both an east-west corridor connecting the xeric San Joaquin Desert biome and the mesic biome of the East Bay Hills and a north-south corridor in the Diablo Range (Fig. 7). If the Corral Hollow population of FYLF recovers under CESA protection, it could serve

[19] Lind, A. J. 2005. Reintroduction of a declining amphibian: determining an ecologically feasible approach for the foothill yellow-legged frog (*Rana boylii*) through analysis of decline factors, genetic structure, and habitat associations. Doctoral dissertation, University of California, Davis.

[20] Lind, A. J., P. Q. Spinks, G. M. Fellers, and H. B. Shaffer. 2011. Rangewide phylogeograpy and landscape genetics of the Western U. S. endemic frog *Rana boylii* (Ranidae): implications for the conservation of frogs and rivers. Conservation Genetics 12:269-284.

as a genetically appropriate source population for reintroduction efforts to historic localities in Contra Costa county in watersheds in the Mount Diablo area[21,22].

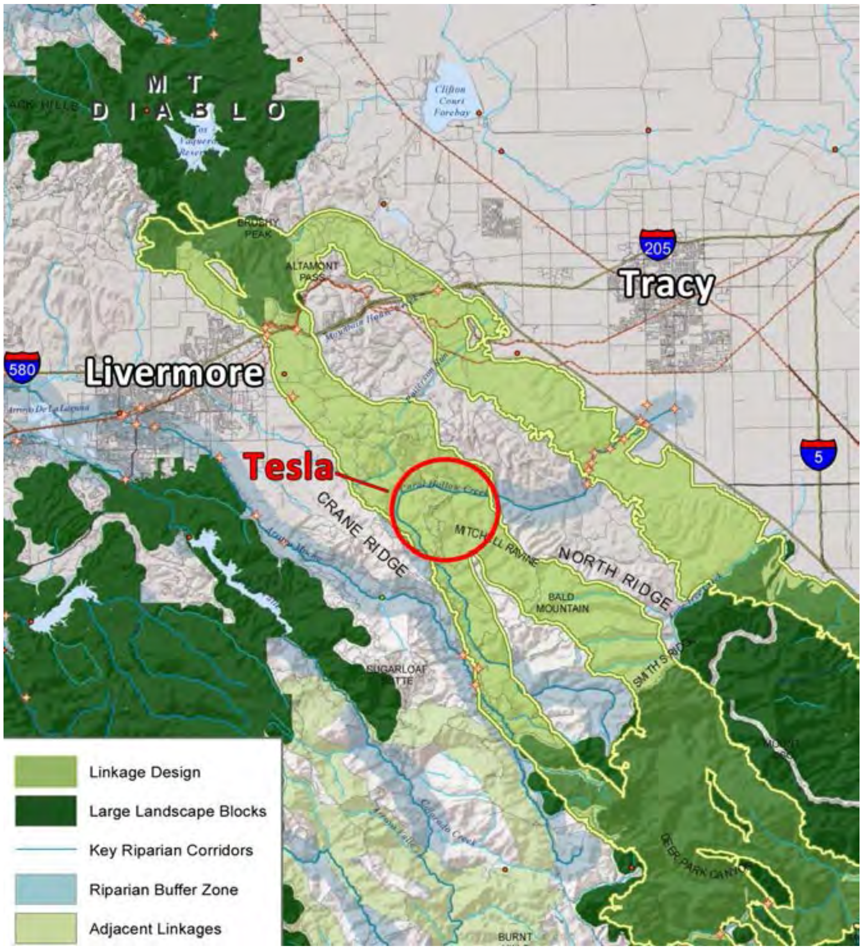

Figure 7. The red circle shows the location of the Tesla Park area (CSVRA expansion area) in a designated critical wildlife linkage corridor[23] between watersheds in Contra Costa Co. and on Mt. Diablo where FYLF are presumed extirpated to the Arroyo Mocho and Corral Hollow watersheds where the frogs are extant. Image reproduced and modified from Penrod et al. 2013.

[21] University of California, Berkeley, Museum of Vertebrate Zoology. Specimen #60187 availabel url [http://arctos.database.museum/guid/MVZ:Herp:60187] accessed 8/11/2015.

[22] Jennings, M.R. and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division. Contract No. 8023. 255 pp.

[23] Penrod, K., P.E. Garding, C. Paulman, P. Beier, S. Weiss, N. Schaefer, R. Branciforte and K. Gaffney. 2013. Critical Linkages: Bay Area & Beyond. Produced by Science & Collaboration for Connected Wildlands, Fair Oaks, CA

5 CONCLUSION

Thank you for the opportunity to share our observations of a significant threat to FYLF that exists on publicly owned lands and should be taken into consideration when developing conservation strategies and making a listing determination under the California Endangered Species Act. The examples provided from CSVRA illustrate the significant threats to FYLF posed by OHV use. Because the management practices we have highlighted are OHMVR Division state-wide policies, it must be assumed that similar risks exist throughout the species range in California where OHV use occurs. If FYLF were protected by the California Endangered Species Act, management of OHV use and expansion of OHV use into sensitive areas could be more effectively regulated.

Given this case study and other information about the species, we urge California Fish and Game Commission to provide full protection to Foothill yellow-legged frog under the California Endangered Species Act including: (1) conducting a full status review of FYLF; (2) listing FYLF as threatened; and (3) designating the Corral Hollow Creek watershed as part of the Critical Habitat needed to maintain what will likely prove to be a Distinct Population Segment. The protection of FYLF habitat on the public land known as Tesla is particularly urgent given the degradation of habitat occurring downstream within the existing CSVRA.

Please contact us at Friends of Tesla Park, PO Box 2502, Livermore, CA 94551, Friendsofteslapark@gmail.com, for questions or information regarding this letter.

Sincerely yours,

Nancy Rodrigue
Friends of Tesla Park
friendsofteslapark@gmail.com
www.teslapark.org

Kerry Kriger, Ph.D.
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Meredith Hendricks
Land Programs Director, Save Mount Diablo
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Norman La Force
SPRAWLDEF
n.laforce@comcast.net

Patterson, Laura@Wildlife

From: Holly Dalton
Sent: Monday, August 21, 2017 9:14 PM
To: Wildlife Management
Subject: Frog status..

The bull frogs and little yellow frogs have been gone in mendocino country for years, we have no surf fish left on the Fort Bragg coastal ranges the deer populationis almost non exesstant.. it is really sad.

Patterson, Laura@Wildlife

From: Sarah Kupferberg
Sent: Tuesday, August 22, 2017 12:30 PM
To: Patterson, Laura@Wildlife
Subject: copies of reports, previous letters to USFWS, re Rana boylii and a query about electro-fishing
Attachments: Kupferberg etal 2013 final report 3.24.13.pdf; peek kupferberg catenazzi.pdf; USFWS boylii letter from Angelo Reserve.pdf; Kupferberg Lind and Palen Population Model final report.pdf

Hello Laura,
I response to the call for information regarding Rana boylii I wanted to provide you with copies of reports and letters I have written in the past that are not as easily accessed as journal articles. It has recently come to my attention that links to the various CEC reports that were previously on a UC Davis website are no longer active and that the reports are also missing from the CEC's website. I am attaching files to this e-mail, but also wanted to generally offer my services in helping you track down material if you need it. For example I have hard copies of some Master's theses on boylii (Tom Van Wagner, Earl Gonsolin) that I could loan.

On another front entirely, I wanted to pass along a question from some salmonid fish researchers working at the Angelo Reserve where I do much of my work In the course of their electrofishing to catch pit-tagged steelhead, they routinely shock Rana boylii. They wanted to know if CDFW had guidance or recommendations. Should they go through sites and try to catch and remove frogs prior to shocking for fish to avoid 'by-catch' of frogs. I did not personally witness how the frogs reacted to elector-fishing, but they said that it looked pretty dramatic, the frogs go completely rigid, but as soon as the current is turned off they very rapidly swim away and disappear. They also wanted to know if the candidacy status would affect their reporting requirements on their scientific collecting permits. I understand that you are not the one granting SCP's for fisheries, but am wondering if the team of people who cover salmonid SCP's are in the loop, so to speak.

Please don't hesitate to ask if there are any ways that I can help in the information gathering process.

-sk

Patterson, Laura@Wildlife

From: House, Matt
Sent: Wednesday, August 23, 2017 2:48 PM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog
Attachments: FYLF_GDRCo_CommentLetter_8-21-2017_final.pdf

Attached please find a comment letter from Green Diamond Resource Company regarding your request for information relevant to a proposal to list the foothill yellow-legged frog.

-Matt

GREEN DIAMOND RESOURCE COMPANY

California Timberlands Division
P.O. Box 1089
Arcata, California
95518-1089

T (707) 668-4400
F (707) 668-4402
www.greendiamond.com

August 21, 2017

California Department of Fish and Wildlife
Attn: Laura Patterson
1812 Ninth St.
Sacramento, CA 95811

RE: Information relevant to a proposal to list the Foothill Yellow-legged Frog as threatened under the California Endangered Species Act.

Dear California Department of Fish and Wildlife:

Green Diamond Resource Company, California Timberlands Division (Green Diamond) is submitting information in response to your solicitation for material relevant to a proposal to list the foothill yellow-legged frog as threatened under the California Endangered Species Act.

Historical and current range and population levels: Foothill yellow-legged frogs (FYLF) have been documented since 1993 on Green Diamond California timberlands when aquatic surveys began in earnest and have a distribution that includes lotic habitats from relatively large rivers to zero-order (Strahler 1957) streams. Efforts to document the distribution of this species have included various types of biological assessment and monitoring surveys that have been conducted along watercourses throughout Green Diamond's California ownership (currently ~ 365,000 acres). Based on the information compiled to date, relatively large rivers and streams throughout Green Diamond's ownership (e.g., Van Duzen River, Eel River, Mad River, Redwood Creek, Klamath River, and Smith River) as well as lower portions of adjoining smaller tributaries (e.g., Cañon Creek, North Fork Mad River, Roach Creek, Tectah Creek, and Terwer Creek) provide suitable breeding habitats for FYLF. We have also documented that many adjoining tributaries to these breeding habitats are often occupied by adult and juvenile frogs and we believe these habitats provide suitable resources for juvenile rearing, summer foraging, and overwintering. During all but one of these survey types, observations of FYLF were supplemental to the survey objectives. One survey effort has been conducted by Green Diamond since 2008 to monitor trends in a subpopulation of FYLF in the Mad River watershed within timberlands owned by Green Diamond. Green Diamond biologists have been conducting the FYLF egg mass surveys annually and surveys are planned to continue.

This study has consisted of annual surveys along an approximate 2.2 km reach in the lower portion of the Mad River near Blue Lake, CA (Figure 1). Preliminary results from this study are presented below (Figure 2). Since initiation, 5,556 egg masses have been documented. The annual average density of egg masses over 10 years of surveys is 258 egg masses per km. These density estimates of egg masses equate to a minimum estimate of female FYLF that deposited the eggs (Wheeler and Welsh 2008).

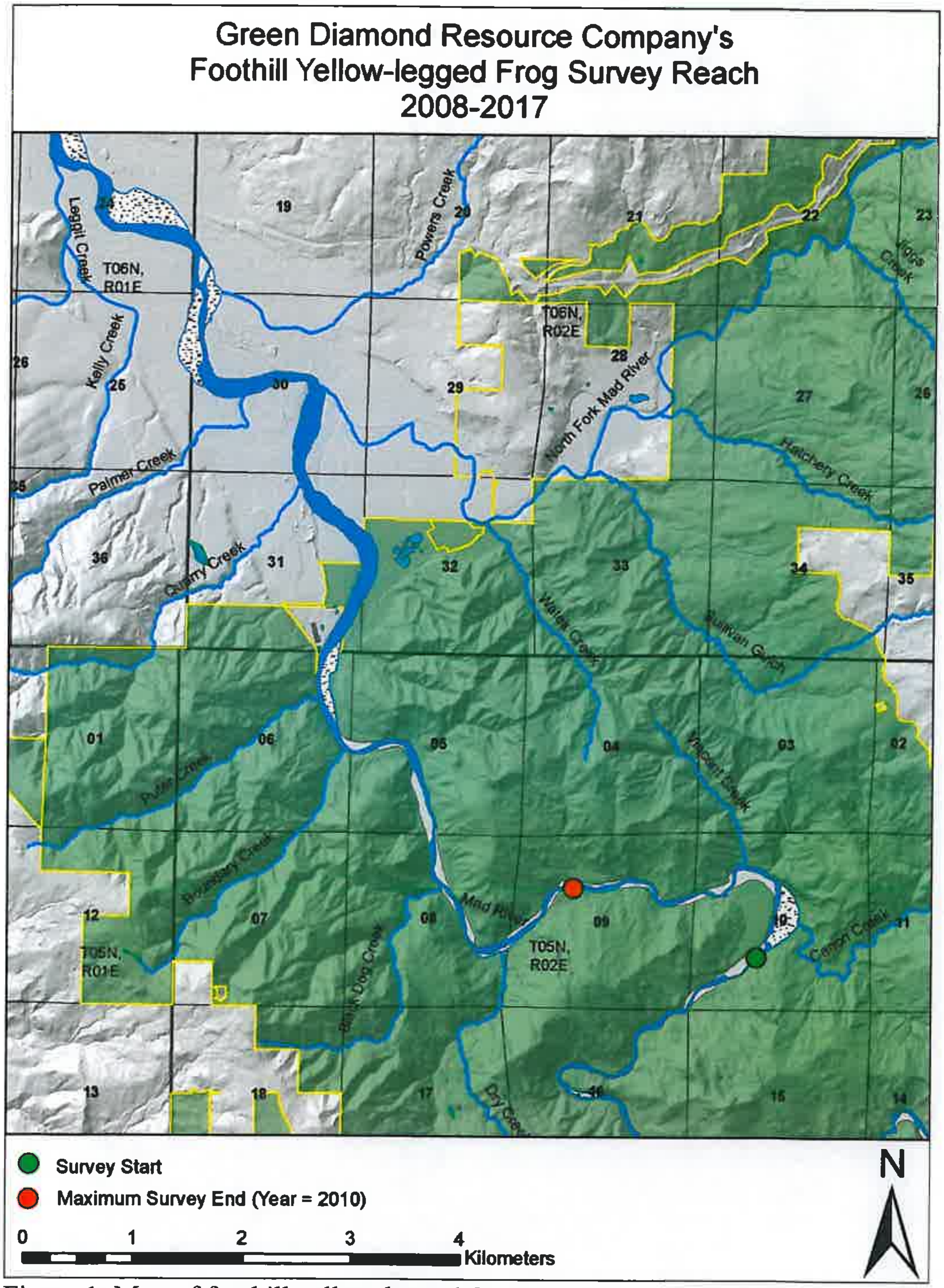


Figure 1. Map of foothill yellow-legged frog egg mass survey reach along the Mad River on Green Diamond California timberlands near Blue Lake, CA.

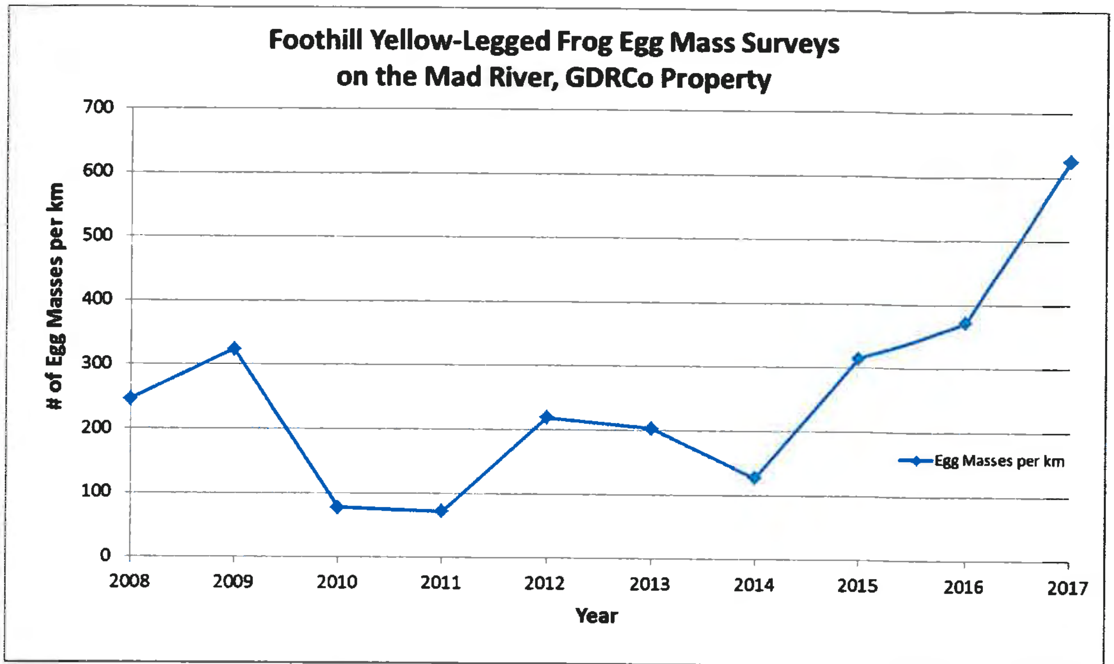


Figure 2. Foothill yellow-legged frog egg mass densities observed along the Mad River during annual survey efforts on Green Diamond California timberlands near Blue Lake, CA from 2008 to 2017.

In 2009, an egg mass density of 323.6 per km was the highest number documented for this monitoring project, which is also the highest density documented for the species (Bourque and Bettaso 2011). The 2017 survey exceeded that documented in 2009 with 625 egg masses per km. Based on the results of this annual survey, this population within the Mad River watershed appears to be very robust and has been increasing in numbers in recent years.

Past and ongoing conservation measures for species and its habitats:

In 2007, National Marine Fisheries Service and the U.S. Fish and Wildlife Service approved an Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances (AHCP) for implementation on over 400,000 acres of Green Diamond's timberlands in northern California. Despite the FYLF not being among the six covered species in the AHCP, the conservation measures and riparian management measures of the plan also provide protections for FYLF habitat. Green Diamond's AHCP includes conservation measures for riparian management, slope stability, road management, and harvest-related ground disturbance that provide protections for FYLFs. The benefits of the riparian management measures are to maintain and enhance key riparian functions such as providing temperature control, nutrient inputs, channel stability, sediment control and large woody debris recruitment potential for streams. The slope stability measures are designed to minimize management-related landslides and sediment delivery to streams. The road management measures are designed to reduce sediment delivery into watercourses from road sources, including surface erosion from roads, road-related landslides and watercourse crossing failures. Additionally the road measures include water drafting provisions that limit drafting during low flows and provide screen specifications to avoid impinging animals. The harvest-related ground disturbance measures are designed to reduce sediment delivery to watercourses from harvest activities by minimizing soil disturbance, soil compaction, and with time-of-year operating restrictions. Collectively the measures were designed to avoid or address specific impacts and provide habitat improvements for the covered species but many of these measures should also serve to ensure the conservation of FYLF habitats.

While Green Diamond's AHCP is focused on cold-water adapted species and is not designed to create more open canopy situations with increased solar input and warmer water temperature conditions favorable to FYLF, the current conservation measures provide protection for FYLF habitats. The conditions along the larger watercourses that are breeding habitats are likely to remain suitable to FYLF due to the width of the watercourses and ample sunlight on these systems.

The benefits of Green Diamond's AHCP should be considered with any assessment of potential impacts of current forest practices on FYLF populations in north coastal California. In addition, the California Forest Practice Rules provide specific protection for watercourses and lakes during timber harvest activities that receive mandatory permits after a review by the lead agency, California Department of Forestry and Fire Protection. Green Diamond assesses potential FYLF habitat during the preparation and review of each timber harvest plan.

After considering the potential impacts of Green Diamond's current forest management practices on FYLF, we believe our existing management is effective at minimizing potential impacts to FYLF and their habitat. Additionally the FYLF population assessment that GDRCo conducts on a segment of stream along the Mad River suggests that this species has a large number of breeding females annually per km with pronounced increasing numbers in recent years.

Green Diamond appreciates the opportunity to provide comments and information to the California Department of Fish and Wildlife on FYLF distribution, abundance and adequacy of existing management strategies in managed timberlands of north coastal California for consideration during the status review for this species.

Sincerely,

Keith A. Hamm
Conservation Planning Manager
Green Diamond Resource Company

References:

Bourque, R. M. and J. B. Bettaso (2011). "Rana Boylii (Foothill Yellow-legged Frog), REPRODUCTION." Herpetological Review 42(4): 589.

Strahler, A. N. (1957). "Quantitative Analysis of Watershed Geomophology." Transactions of the American Geophysical Union 38(6): 913-920.

Wheeler, C.A. and H.H. Welsh (2008). "Mating strategy and breeding patterns of the Foothill Yellow-legged Frog (*Rana boylii*)." Herpetological Conservation and Biology 3(2): 128-142.

Patterson, Laura@Wildlife

From: Kristen Hein Strohm
Sent: Thursday, August 24, 2017 8:07 PM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog

Dear Ms. Patterson,

Sierra Streams Institute has collected data on foothill yellow-legged frog (*Rana boylii*) populations, habitat conditions, and anthropogenic impacts at several sites in the Bear and Yuba watersheds in the northern Sierra Nevada during the past two breeding seasons. We have also tested frogs for chytrid fungus at several sites in both watersheds, and have collaborated with Ryan Peek of UC Davis. We respectfully request that the results of these scientific studies be considered along with the other available statewide data in CDFW's 12-month status review for this species. We also request that Tom Van Wagner's data from studies in Clear Creek and Shady Creek be considered; it is our understanding that he will be submitting those data separately.

I have attached a preliminary report of Sierra Streams Institute's Bear River Watershed visual encounter surveys performed in 2016. Our 2017 data is currently being entered, QCed, and analyzed. I will submit the 2017 report by the end of October 2017. That report will contain substantial information about habitat conditions and impacts within the Bear River Watershed. It will also delineate the locations of foothill yellow-legged frogs observed within the footprint of the proposed Centennial Reservoir on the Bear River.

Sierra Streams Institute's 2017 report will also contain more information on our chytrid test methodology, coordinates of the sites where we collected skin swabs, and more. In the mean time, here is a brief summary of the chytrid results. All skin swab samples were tested for chytrid at the Amphibian Disease Lab at the San Diego Zoo.

Chytrid results for foothill yellow-legged frogs swabbed in spring/summer 2016 under the direct supervision of Ryan Peek and performed under his permit:

- Steephollow Creek upstream of its confluence with the Bear River and downstream of Lowell Hill Rd: 8/10 positive
- Bear River near the Chicago Park Powerhouse: 3/5 positive
- Greenhorn Creek near Hwy 174: 1/3 positive (the positive one was a California toad found dead at the water's edge; all other swabs this year were from foothill yellow-legged frogs)
- Clear Creek: 0/4 positive

Chytrid results for American bullfrogs swabbed in spring/summer 2015 under Sierra Streams Institute's scientific collecting permit:

- 3/3 tested positive at the confluence of Deer & Squirrel Creeks
- 1/1 tested positive on Squirrel Creek upstream of the Deer Creek confluence
- 3/5 tested positive on Deer Creek above Lake Wildwood
- 0/4 tested positive in Lower Scotts Flat Lake

With gratitude and best wishes,

Kristen Hein Strohm
Wildlife Biologist
Sierra Streams Institute

Patterson, Laura@Wildlife

From: Kim McHenry
Sent: Friday, August 25, 2017 9:23 PM
To: Wildlife Management
Subject: Foothill yellow legged frog

Im 73 years old and raised nearly 1 million dollars for CWA over 17 yrs (colusa crab cioppino dinners) i have barged 1 million salmon smolts to the golden gate .
I have a 65 ft comm. fishing vessel which i fished for 57 years.
I also farm 600 acres of rice in maxwell ca.
I have seen the egret and blue heron population multiply hundreds of times in the last 60 yrs. If you will go to youre frog pond at early and late hrs. You will see unbelievable tadpole and frog predation from these beautiful birds, i have watched the same animals reduce the bulfrog population to nearly zero in all waterways in sac valley.
Having always being extremely observant i know see these birds n huge flocks in coastal red legged frog habitate.
If you will spend a couple of hrs w field glases observing you eill see where all the frogs have gone. Sometimes by protecting one species you have inadvertantly upset natures way. Dont blame every one and everything, the answer is right in front of you!
Michael d mchenry

Sent from my iPhone

From: Michael Westphal
Sent: Monday, August 28, 2017 6:13 PM
To: Patterson, Laura@Wildlife
Subject: Rana boylii request for information

Hi Laura,

Can you please accept this as my response to your request for information regarding the foothill yellow-legged frog, Rana boylii.

Rana boylii is considered to be a "Sensitive Species" and thus a focus of management planning by BLM.

Rana boylii is present on lands managed by Bureau of Land Management within the jurisdiction of the Central Coast Field Office.

We know them to be present in numerous creeks converging on San Benito Mountain within the Clear Creek Management Area in San Benito and western Fresno Counties.

I have also observed them frequently in Laguna Creek where it is forded by Coalinga Road in San Benito County. In the past two years I have not seen them there.

I have observed them in Cantua Creek on private and public lands in west Fresno County, most recently in 2013.

This summer I observed a small population in Jacalitos Creek, west Fresno County, in the Devil's Gate gorge.

I know them to be present in Del Puerto Creek, in Sulphur Creek (a tributary of Smith Creek on Mt. Hamilton) and in Soquel Creek in the Santa Cruz Mountains.

I have also observed them breeding in Cazadero Creek in Sonoma County.

A major concern of mine is that, should Clear Creek Management Area be re-opened to off-road vehicular use, as has been proposed in the US Congress, siltation and other effects of OHV will negatively impact the species. At present CCMA is closed to OHV use.

I would be happy to supply more precise locality data, and to elaborate on potential threats to any of the above-named populations, should you so desire.

Thank you for allowing me to contribute to this matter,

Mike Westphal
Ecologist
US Bureau of Land Management

Sent from my iPad

Patterson, Laura@Wildlife

From: Anderson, David
Sent: Thursday, August 31, 2017 8:53 AM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog
Attachments: Yellowlegged frog survey RedwCr 8-28-2017.pdf; 2016 REDW CR SSHD REPORT.pdf; Deformed Frog Survey Report fy 2001.pdf; Deformed Frog Survey Report fy 2002.pdf; Deformed Frog Survey Report fy 2003.pdf; Deformed Frog Survey Report fy 2004.pdf; Deformed Frog Survey Report fy 2005.pdf

Laura Patterson,

Attached are a number of reports from Redwood National Park of Yellow-legged frog monitoring or notes on Redwood Creek, Humboldt County, within the park.

The early reports (2001-2005) are deformed frog surveys on mainstem Redwood Creek between Forty-four Creek and Bond Creek confluences.

The 2016 summer steelhead report has information in the wildlife observed table that shows their occurrence when noted in the 24 mile survey Redwood Creek reach as well as numbers counted in a short reach from Lacks to Panther Creeks.

In a survey done this week (8/28/2017) of Redwood Creek from Forty-four Creek to Bond Creek, numbers of adults and young frogs are reported.

If you have any questions, please contact me at the phone number or email listed below.

David Anderson

--
David G. Anderson
Fishery Biologist
Redwood National and State Parks
121200 Highway 101 P.O. Box 7
Orick, California 95555
707 465-7771 ph

Patterson, Laura@Wildlife

From: Don Ashton
Sent: Thursday, August 31, 2017 11:01 PM
To: Wildlife Management
Subject: Foothill Yellow-legged Frog
Attachments: FYLF_AshtonComments.pdf

Laura,
I have been quite busy in the field summer (with limited internet access), but would like to add my comments for your consideration in the FYLF listing decision. I will be more available (i.e., in the office) through the fall and winter if additional information is needed.

Thank you for your careful consideration during this review process.
--
Don Ashton

California Department of Fish and Wildlife
Attn: Laura Patterson *(916) 341-6981*
1812 Ninth St.
Sacramento, CA 95811

31 August 2017

Email: wildlifemgt@wildlife.ca.gov.
subject: "Foothill Yellow-legged Frog"

I am writing to provide California Department of Fish and Wildlife (CDFW) with information relevant to the current proposal to list the Foothill Yellow-legged Frog (*Rana boylii*, FYLF) as a threatened species under the California Endangered Species Act.

As you may know already, I have studied FYLF in Northern California for many years, and much of my work has focused on impacts related to downstream effects of dams and ways to improve flow management to reduce those impacts. And while those efforts have led to incremental benefits to populations downstream of dams, population recovery has been slow. Added pressures of climate change and the largely unregulated marijuana industry have potential to ameliorate any gains made by improved flow management for this already imperiled species.

Reproductive success of FYLF in my study areas in the Trinity River, Trinity County was very low this year. High flows in the Spring delayed onset breeding. Subsequently, rapidly descending hydrograph led to desiccation of nearly all eggmasses observed. I can provide a detailed report of our observations this summer once the data has been fully processed and reviewed following the end of the field season.

This comment period occurs during an especially busy time for us actively working in the field, so I am limited on time to provide a through summary of currently available information, but urge you to consult recent publications and consult with those involved in ongoing research with this species during your review. I will be in the field though much of September and the first half October, but should be much more available later autumn and through the winter. Please don't hesitate to contact me for additional information during the review process.

Thank you,

Don Ashton

Patterson, Laura@Wildlife

From: Stanish, Anastasia@CALFIRE
Sent: Thursday, August 31, 2017 3:24 PM
To: Patterson, Laura@Wildlife
Subject: FW: approved, signed FYLF letter
Attachments: CAL FIRE Foothill Yellow-Legged Frog Letter Aug 31, 2017.pdf

Laura, please see the attached letter from CAL FIRE providing data from Soquel State Forest. Thanks for the opportunity to provide information. As my supervisor indicates below, a hard copy is in the mail.

Stacy Stanish, RPF No. 3000
Senior Environmental Scientist - Forest Practice Biologist
CAL FIRE
CA Department of Forestry and Fire Protection
6105 Airport Road
Redding, CA 96002
Phone: (916) 616-8643

From: Cafferata, Pete@CALFIRE
Sent: Thursday, August 31, 2017 3:12 PM
To: Stanish, Anastasia@CALFIRE
Cc: Coe, Drew@CALFIRE ; Huff, Eric@CALFIRE ; Hall, Dennis@CALFIRE ; Spencer, Michelle@CALFIRE
Subject: approved, signed FYLF letter

Stacy:
Here is approved, signed FYLF letter. I am assuming you want to submit this to DFW staff. Michelle will mail the hard copy.
Thanks.
Pete

Pete Cafferata
Watershed Protection Program Manager, Forester III
California Department of Forestry and Fire Protection
PO Box 944246
Sacramento, CA 94244
Office: (916) 653-9455

DEPARTMENT OF FORESTRY AND FIRE PROTECTION
P.O. Box 944246
SACRAMENTO, CA 94244-2460
(916) 653-7772
Website: www.fire.ca.gov

August 31, 2017

Laura Patterson
California Department of Fish and Wildlife
1812 9th Street
Sacramento, California 95811

Subject: Data and Comments on the Status Review of the Foothill Yellow-Legged Frog (*Rana boylii*)

Dear Ms. Patterson:

The California Fish and Game Commission voted to make Foothill Yellow-Legged Frog (*Rana boylii*) (FYLF) a "threatened" candidate species under the authority of the California Endangered Species Act at the June 2017 Commission meeting. As such, California Department of Fish and Wildlife (CDFW) is conducting a Status Review and accepting input for the species during its candidacy. The California Department of Forestry and Fire Protection (CAL FIRE) appreciates the opportunity to provide data and comments as you develop the Status Review for FYLF.

CAL FIRE is the lead agency that regulates timber harvesting activities on approximately seven million acres of private and state forestland in the State of California under the authority of the California Forest Practice Act and Rules. These rules are intended to preserve and protect fish, wildlife, and other natural and cultural resources. Additionally, CAL FIRE manages eight Demonstration State Forests, totaling about 71,000 acres. The forests are managed through the development of Timber Harvesting Plans (THP's) that address and mitigate potential impacts to listed and special status species. Typical THPs identify whether a proposed project is within the range of such a species, if habitat is present, and if individuals are known to be present. Mitigation and avoidance measures may then be proposed if any of those conditions exist.

According to the CDFW's Biogeographic Information and Observation System (BIOS), FYLF range layers indicate that all of the Demonstration State Forests are within the range of FYLF. For the most part, FYLF protocol or visual encounter surveys for the species have not been conducted on the Demonstration State Forests, with the exception of Soquel Demonstration State Forest (SDSF). SDSF is located in Santa Cruz County, where the East Branch of Soquel Creek and its tributaries flow through the Forest.

In the Center for Biological Diversity's "*Petition to List the Foothill Yellow-Legged Frog (Rana boylii) as Threatened Under the California Endangered Species Act*," population data ranging from 1992-2008 were reported for Soquel Creek from a California Natural Diversity Database (CNDDB) search in 2016, with the narrative qualification that populations were small to moderate. In order to provide current information and data, a local volunteer herpetology group in Santa Cruz has been conducting annual surveys for amphibians and reptiles, including FYLF, since 2011. As part of the conditions of their scientific collecting permit, results of the surveys are regularly submitted for inclusion in the CNDDB. For ease of access, an abbreviated version of the data with occurrence locations previously submitted to the CNDDB is attached as a table at the end of this letter. General information and photos of individuals, egg masses, and habitat from those surveys can also be found at the following location: naherp.com. The volunteer herpetologists plan to continue regular surveys and to provide their results to the CNDDB.

CAL FIRE looks forward to the findings of CDFW's Status Review and to providing further input. If you have any questions or comments regarding this letter, please contact CAL FIRE Forest Practice Biologist, Stacy Stanish at Anastasia.Stanish@fire.ca.gov or (916) 616-8643.

Sincerely,

HELGE ENG
Deputy Director
Resource Management

Foothill Yellow-Legged Frog survey results relative toSoquel Creek and Soquel Demonstration State Forest:

Date	Time	Locale	Latitude	Longitude	Datum	Method	Age	Qty
10/13/11	16:26	Soquel Creek SDSF	37.07768	-121.921	NAD27	Visual encounter	YoY	1
07/08/12	15:45	Soquel Creek downstream for Long Ridge	37.07647	-121.924	WGS84	Visual encounter	Larva	8
07/08/12	16:00	Soquel Creek 50' downstream for Long Ridge	37.07823	-121.921	WGS84	DOR	Larva	5
09/16/12	10:32	Soquel Creek below bridge	37.07402	-121.924	WGS84	Visual encounter	YoY	1
09/18/12	9:15	Soquel Creek below bridge	37.07293	-121.926	WGS84	Visual encounter	YoY	1
09/18/12	10:20	Soquel Creek below bridge	37.07215	-121.925	WGS84	Visual encounter	YoY	3
05/16/13	14:00	Soquel Creek SDSF	37.07883	-121.92	WGS84	Visual encounter	Juvenile	2
05/16/13	14:05	Soquel Creek SDSF	37.07883	-121.92	WGS84	Visual encounter	Larva	61
05/16/13	14:10	Soquel Creek SDSF	37.07925	-121.92	WGS84	Visual encounter	Juvenile	1
05/02/15	13:10	Sulfurs Spring on Sulfur Springs Rd	37.08514	-121.888	WGS84	Visual encounter	Juvenile	4
05/02/15	15:18	SDSF Soquel Creek below bridge	37.07311	-121.925	WGS84	Visual encounter	Eggs	1
05/02/15	15:19	SDSF Soquel Creek below bridge	37.07345	-121.924	WGS84	Visual encounter	Juvenile	1
05/02/15	15:44	SDSF Soquel Creek below lower bridge crossing	37.07314	-121.925	WGS84	Visual encounter	Sub-Adult	1
05/02/15	15:45	Soquel Creek downstream from lower bridge	37.07231	-121.925	WGS84	Visual encounter	Larva	1
05/02/15	16:20	Soquel Creek downstream from lower bridge	37.07289	-121.926	WGS84	Visual encounter	Eggs	2
05/02/15	16:20	Soquel Creek downstream from lower bridge	37.073	-121.925	WGS84	Visual encounter	Larva	3
05/02/15	16:25	Soquel Creek downstream from lower bridge	37.07289	-121.926	WGS84	Log flipping	Adult	2
05/02/15	16:40	Soquel Creek downstream from lower bridge	37.07244	-121.925	WGS84	Visual encounter	Eggs	2
09/11/15	14:30	Soquel Creek SDSF	37.09143	-121.885	WGS84	Visual encounter	Juvenile	1
09/27/15	10:42	Soquel Creek SDSF	37.09265	-121.888	WGS84	Visual encounter	Juvenile	2
09/27/15	10:50	Soquel Creek SDSF	37.09267	-121.887	WGS84	Visual encounter	Juvenile	1
09/27/15	11:45	Soquel Creek SDSF	37.09357	-121.892	WGS84	Visual encounter	Varying	4
09/27/15	14:25	Soquel Creek SDSF	37.08772	-121.902	WGS84	Visual encounter	Adult	1
09/27/15	14:30	Soquel Creek SDSF	37.08663	-121.903	WGS84	Visual encounter	Adult	1
09/27/15	14:35	Soquel Creek SDSF	37.0867	-121.903	WGS84	Visual encounter	Adult	1
09/27/15	15:00	Soquel Creek SDSF	37.0848	-121.907	WGS84	Visual encounter	Adult	1
09/27/15	15:04	Soquel Creek SDSF	37.08475	-121.908	WGS84	Rock flipping	Adult	1
09/27/15	15:20	Soquel Creek SDSF	37.08358	-121.91	WGS84	Rock flipping	Adult	1
09/27/15	15:23	Soquel Creek SDSF	37.08357	-121.91	WGS84	Visual encounter	Adult	2
09/27/15	15:35	Soquel Creek SDSF	37.0838	-121.912	WGS84	Visual encounter	Adult	2
10/11/15	11:05	Soquel Creek SDSF	37.08708	-121.865	WGS84	Visual encounter	Juvenile	2
10/11/15	11:20	Soquel Creek SDSF	37.08738	-121.866	WGS84	Visual encounter	Metamorp	3
10/11/15	11:30	Soquel Creek SDSF	37.0876	-121.866	WGS84	Visual encounter	Metamorp	4
10/11/15	11:50	Soquel Creek SDSF	37.08795	-121.867	WGS84	Visual encounter	Varying	6
10/11/15	13:30	Soquel Creek SDSF	37.09053	-121.877	WGS84	Visual encounter	Adult	1
10/11/15	13:50	Soquel Creek SDSF	37.09073	-121.88	WGS84	Rock flipping	Juvenile	1
05/22/16	0:35	Soquel Creek SDSF	37.0937	-121.891	WGS84	Visual encounter	Larva	4
05/22/16	11:20	Soquel Creek SDSF	37.09262	-121.886	WGS84	Visual encounter	Larva	4
05/22/16	11:30	Soquel Creek SDSF	37.09243	-121.887	WGS84	Visual encounter	Larva	1
05/22/16	11:45	Soquel Creek SDSF	37.0931	-121.888	WGS84	Visual encounter	Larva	3
05/22/16	13:00	Soquel Creek SDSF	37.09338	-121.892	WGS84	Visual encounter	Larva	1
05/22/16	13:50	Soquel Creek SDSF	37.09153	-121.895	WGS84	Visual encounter	Larva	2
05/22/16	14:10	Soquel Creek SDSF	37.09158	-121.896	WGS84	Visual encounter	Larva	4
05/22/16	14:28	Soquel Creek SDSF	37.08907	-121.899	WGS84	Visual encounter	Adult	1
05/22/16	14:55	Soquel Creek SDSF	37.08688	-121.901	WGS84	Visual encounter	Sub-Adult	1
05/22/16	15:04	Soquel Creek SDSF	37.08667	-121.902	WGS84	Visual encounter	Larva	2
05/22/16	15:15	Soquel Creek SDSF	37.08703	-121.904	WGS84	Visual encounter	Larva	3
05/22/16	15:30	Soquel Creek SDSF	37.08672	-121.905	WGS84	Visual encounter	Larva	6
07/30/16	10:35	Soquel Creek SDSF near Fern Gulch X Saw Pit trail	37.08392	-121.91	WGS84	Visual encounter	Adult	1
07/30/16	10:55	Soquel Creek SDSF near Fern Gulch X Saw Pit trail	37.08345	-121.911	WGS84	Visual encounter	Adult	1
07/30/16	11:07	Soquel Creek SDSF near Fern Gulch X Saw Pit trail	37.08383	-121.912	WGS84	Visual encounter	Adult	1
07/30/16	11:30	Soquel Creek SDSF below Saw Pit trail	37.08363	-121.913	WGS84	Visual encounter	Larva	1
07/30/16	13:15	Soquel Creek SDSF below Saw Pit trail	37.07552	-121.925	WGS84	Visual encounter	Larva	2
07/30/16	13:27	Soquel Creek SDSF near Long Ridge Rd.	37.0749	-121.926	WGS84	Visual encounter	Larva	1
07/30/16	13:45	Soquel Creek SDSF Below bridge.	37.07188	-121.925	WGS84	Visual encounter	Larva	1
07/30/16	14:00	Soquel Creek SDSF Below bridge.	37.07283	-121.926	WGS84	Visual encounter	Adult	1
07/30/16	14:15	Soquel Creek SDSF Below bridge.	37.07112	-121.926	WGS84	Visual encounter	Larva	1
07/30/16	14:15	Soquel Creek SDSF Below bridge.	37.0695	-121.926	WGS84	Visual encounter	Adult	1
10/08/16	10:30	Amaya Creek	37.08278	-121.929	WGS84	Visual encounter	Adult	1
10/08/16	11:19	SDSF Amaya Creek	37.0806	-121.928	WGS84	Visual encounter	Adult	1
10/08/16	11:52	SDSF Amaya Creek	37.0791	-121.928	WGS84	Visual encounter	Adult	1
10/08/16	12:41	SDSF Amaya Creek	37.07547	-121.926	WGS84	Visual encounter	Adult	1
10/08/16	12:45	SDSF Amaya Creek	37.07891	-121.928	WGS84	Visual encounter	Adult	1
10/08/16	13:15	SDSF Amaya Creek	37.0774	-121.928	WGS84	Visual encounter	Adult	1
07/21/17	11:00	SDSF Sue's Creek	37.08317	-121.9	WGS84	Visual encounter	Sub-Adult	1
07/21/17	12:15	SDSF Sue's Creek	37.08323	-121.899	WGS84	Visual encounter	Adult	3

Patterson, Laura@Wildlife

From: Cedric Twight
Sent: Thursday, August 31, 2017 5:09 PM
To: Patterson, Laura@Wildlife
Subject: Sierra Pacific Ind_FYLF_comment letter 8-31-2017
Attachments: SPI FYLF listing comment letter_p.pdf

Laura Patterson,
Attached find Sierra Pacific Industries initial comments regarding the potential listing of the FYLF.

Cedric Twight
Manager of California Regulatory Affairs
Sierra Pacific Industries
P.O. Box 496014
Redding, CA 96049-6014

SIERRA PACIFIC INDUSTRIES

SIERRA PACIFIC INDUSTRIES

Forestry Division • P.O. Box 496014 • Redding, California 96049-6014
Phone (530) 378-8000 • FAX (530) 378-8139

August 31, 2017

California Department of Fish and Wildlife
Attn: Laura Patterson
1812 Ninth St.
Sacramento, CA 95811

Dear Laura Patterson,

This letter is in response to the California Fish and Wildlife is seeking information that relates to its decision to accept for consideration the petition submitted to list foothill yellow-legged frog (FYLF) as a threatened species under the California Endangered Species Act.

Sierra Pacific Industries (SPI) has not done extensive surveys of its forestlands for FYLF, however we have identified FYLF in several streams over the last 20 years. In some instances SPI resource managers have re-surveyed areas after timber harvesting activities were completed. See the table below for the name of the stream where FYLF surveys have occurred, the number of individual FYLF observed and surveyor comments.

CA 2.2 Watershed	Year of Survey	Stream Name Surveyed	Visual Encounter Surveyor	Frog count	Egg mass count.	Comments
McCormick Creek	2017	Long Canyon Creek	Luke Wagner	6	0	N/A
McCormick Creek	2017	Griswold	Kym Underwood	12	0	N/A
Lower Panther Creek	2017	Unnamed Class II	Luke Wagner	1	0	N/A
5517.530301	2017	Near St. Catherine's creek	Joe King	3	0	N/A
5517.410101	2016	Trib. of Oregon Creek	Dario Davidson	2	0	N/A
5517.540003	2014	Trib. of North fork of North fork American R.	Amanda Shufelberger	3	0	N/A
5514.550302	2014	Trib. of North fork American R.	Amanda Shufelberger	10	0	N/A

5517.410203	2017	Near Grouse Creek	Sarah Smayda	8	20	
5517.320304	2009	Trib. of South Yuba River	Amanda Shufelberger	1		2010-same results (1 adult)
5517.420202	2009	Indian Creek	Amanda Shufelberger	5		Frogs are there every time I've visited that creek 2010-2017
5516.340202	2015	Steephollow Creek	Carl Bystry	2	0	N/A
5516.340201	2015	Steephollow Creek	Amanda Shufelberger	9	0	N/A
5517.420203	2010	Near Moore's Flat Creek	Amanda Shufelberger	3	0	N/A
5517.320103	2010	Trib. of Trib. of Poorman Creek	Amanda Shufelberger	1	0	N/A
5517.340302	2016	Diamond Creek	Dakota Mork	3	0	N/A
5517.530301	2016	Trib. of Humbug Creek	Dakota Mork	1	0	N/A
5517.530301	2016	Trib. of Little Humbug Crk	Dakota Mork	1	0	N/A
					0	N/A
6534.500505	2001	McCormick Creek	Dan Applebee	1	0	N/A
6534.500505	2001	Long Canyon	Dan Applebee	1	0	N/A
5517.410203	2007	Squirrel Creek	Kevin N Roberts	2	0	N/A
1106.400508	2011	Coffee Creek.	Jessica O'Brien	2	0	N/A
1106.310201	1997	Lower Browns Creek	S. Self, J. Kelley, Boullion	30	0	N/A
5517.420202	2006	Kanaka Creek, near Red Ledge mine, old NDDB site.	Rick Carr (CDF), Kevin N Roberts and DFG	1	0	N/A
6534.500602	2001	Mill Creek	Dan Applebee	1	0	N/A
5514.540002	2010	Government Spring, trib to NF American River	Kevin N Roberts	5	0	N/A
6534.500602	2001	Mill Creek	Dan Applebee	1	0	N/A

5517.320201	2007	Trib to Missouri Canyon, South Yuba River	Daniel Boudreaux	4	0	N/A
6534.220105	2001	Rose Creek	Dan Applebee	1	0	N/A

Although the survey effort for FYLF is far from exhaustive the occurrences of FYLF on SPI forestland appear to be fairly wide spread. This brings into question how much of the available habitat along unregulated streams (streams not subjected to atypical flux flows from dam releases) has been surveyed. Should the Fish and Game Commission require that a more thorough sampling of FYLF habitat on unregulated streams be conducted prior to making a listing decision? A more thorough census of FYLF would provide a good basis for a listing decision and also that data could be used as baseline data for future population and adaptive management assessments.

In researching FYLF data sources to provide information for this letter, the Department's Natural Diversity Database (NDDB) has a large number of observations helpful for your analysis. But, some of the scientific studies conducted in California and cited in the Department's evaluation of the FYLF listing petition are not in the NDDB. Two examples, Bourque (2008) and Wheeler et al. (2015), contain occurrence location information which appear to be absent from NDDB. The locations of scientific studies used in the listing process should be added to the NDDB.

Internet websites, iNaturalist.org and www.naherp.com both contain recent reports of FYLF observations in California which would be relevant to the Department's analysis.

Federal Energy Regulatory Commission permit applications contain many references to FYLF for the various relicensing applications for dams in California. The Department should include information found in these documents.

The Department should consult with their fisheries staff biologists who presumably evaluate stream habitat in deciding when and where to plant fish for recreational fishing. Recent work to evaluate the effects of fish stocking on natural stream processes should include readily available information on frog presence or absence.

Kupferberg et al. (2008) state that the foothill yellow-legged frog's entire life cycle is associated with fluvial environments and adult frogs are almost always found close to water, from small creeks to large rivers, and often use cover within the stream as a primary refuge. Clutches of eggs are laid on in-channel substrates in spring or early summer, and larvae metamorphose in late summer or early fall prior to the onset of the next rainy season's floods. Bourque (2008) used radio telemetry to determine the distance male and female adult frogs moved away from the wetted channel. Bourque's results indicated that in the spring (April-June) and fall/winter (October-January) the maximum distance from water for both males and females was 10.7 m and 40 m respectively. Rombough (2006) indicates that overwintering habitat includes streams/rivers and in tributaries and at seeps along stream/river edges where frogs hide under woody debris and rocks along the stream margins.

Sierra Pacific Industries believes that the California Forest Practice rules provide appropriate protections for the FYLF in 14 CCR 916, 936, 956. In particular the protection measures from 936.4(b) state:

A combination of the rules, the plan, and mitigation measures shall provide protection for the following:

a. Water temperature control.

b. Streambed and flow modification by large woody debris.

c. Filtration of organic and inorganic material.

d. Upslope stability.

e. Bank and channel stabilization.

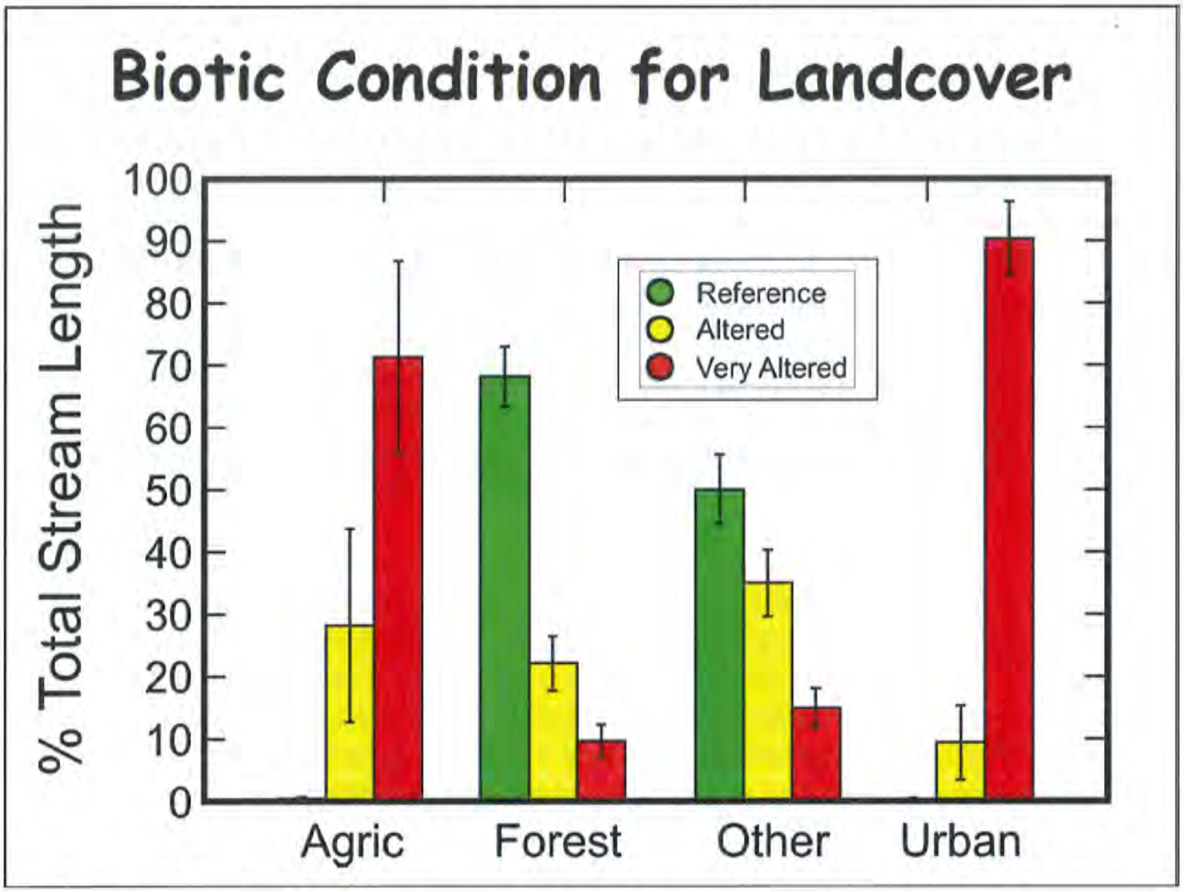
f. Spawning and rearing habitat for salmonids

g. Vegetation structure diversity for fish and wildlife habitat, possibly including but not limited to:

1. Vertical diversity
2. Migration corridor
3. Nesting, roosting, and escape
4. Food abundance
5. Microclimate modification
6. Snags
7. Surface cover"

The California Forest Practice Rules (CFPR) and their implementation through the Timber Harvest Plan (THP) process, which is a certified regulatory program under PRC 21080.5, include an interdisciplinary review team consisting of CAL FIRE (Lead Agency), Regional Water Quality Control Board, California Department of Fish and Wildlife, and California Geological Survey. The lead and responsible agencies assess each THP for its compliance with CFPR, Fish and Game codes, Porter Cologne Water Quality Control Act and CEQA. During THP implementation and following the completion of operations agencies perform regulatory compliance monitoring. In combination, the existing regulations, review, and state agency compliance monitoring means that there is a robust regulatory framework in place to protect FYLF. The Department should acknowledge the work of Registered Professional Foresters, private landowners, and departments and staff of California's Natural Resources Agency in protecting functioning watercourse habitats where FYLF occur.

Because timber harvesting is subject to a robust regulatory framework, timber harvesting should not be considered a significant threat to the ongoing survival of FYLF. The instream and near stream conditions on both industrial and non-industrial private timberlands have been assessed through the Surface Water Ambient Monitoring Program (SWAMP). The SWAMP program is implemented by CDFW scientists and the results from sampling from 2000-2007, as reported by Harrington (2012), is shown in the graphic below.



These SWAMP data provide a good indication of where the threat of habitat alteration exists. Independent of the CDFW SWAMP sampling SPI contracted with the CSU Chico Foundation to collect 35 additional benthic macroinvertebrate (BMI) samples on its timberlands between 2014 and 2016, including many areas that were salvaged logged following wildfire. These samples have all been archived in the California Environmental Data Exchange Network (CEDEN). The reason BMI samples were collected is because macroinvertebrates cannot escape pollution, macroinvertebrates have the capacity to integrate the effects of the stressors to which they are exposed, in combination and over time (US EPA website). Using the BMI samples SPI calculated the California Stream Condition Index (CSCI) scores and output using R scripts defined in Mazor et al. (2015). CSCI score categories were applied as defined in Rehn et al. (2015). Most (n = 29) of the 35 CSCI scores fell into the Likely Intact category with the remaining six samples scoring Possibly Altered. No sample fell into the Likely Altered or Very Likely Altered categories.

After review of the scientific literature on FYLF, it appears that what threatens its existence are water management activities downstream of the 1,250 dams in California under the jurisdiction of the California Department of Water Resources (CDWR 2017). Kupferberg et al. (2008) summarizes the impacts of dams succinctly. "Potential causes are many, but those related to dams and flow regulation are especially ubiquitous. Habitats have been destroyed and fragmented as river channels were converted to reservoirs. Alterations to the disturbance regime and sediment budget of dammed rivers have drastically modified the remaining river channel environment. Predation by nonnative predators such as bullfrogs (*Rana catesbeiana*), fish, and crayfish has increased as these invasive species flourished in California waterways subject to flow diversion and regulation (Moyle and Light 1996; Marchetti et al. 2004). As a result, *R. boylii* have either disappeared or declined to small population sizes relative to nearby populations in unregulated rivers within the same watershed (S. Kupferberg, personal observation, and unpublished USFS data)." Further study by Kupferberg et al. (2012) reports a comparative analysis between FYLF populations prior to 1975 and 1996-2010 on regulated and unregulated rivers in Oregon and California. Kupferberg et al. (2012) reports, "For California presence of dams in the upstream watershed was associated with an absence of frogs. Compared with sites where frogs were present, there were an average of 1.9, 1.6, and 2.1 times more dams (all sizes), large dams, and very large dams, respectively, upstream of sites where frogs were absent at the time of our study, but present before 1975."

Hayes et al. (2016) summaries the threat from dams in the following: "The most robust data implicate water development and diversions as the primary cause of declines in foothill yellow-legged frogs. Water development and diversions are a prominent risk because they result in hydrological changes that chronically affect several aspects of the frog's life history. Recent studies from both regulated and unregulated rivers have demonstrated that small-scale changes in local habitat conditions, such as water velocities, depths, and temperatures, which often result from water management activities and landscape-scale changes, can lead to (1) inconsistent environmental cues for breeding, (2) lower growth rates for tadpoles, (3) scouring or stranding of egg masses and tadpoles, (4) reductions of overall habitat suitability for breeding and rearing, (5) barriers to gene flow around reservoirs, and (6) establishment of nonnative predators in reservoirs that then spread into the rivers."

High intensity wildfire is another threat to FYLF. This is because where wildfires burn at high intensity it kills all the vegetation, removes the protective organic layer from the soil and creates a hydrophobic layer that impedes water infiltration and increases the rate of water run-off, which leads to accelerated sheet, rill and gully erosion. The soil transported downslope following an intense wildfire can cover over aquatic substrates limiting the reproductive success of FYLF (Yarnell 2015). Soil-embedded substrates reduce the amount of refugia for tadpoles to avoid high velocity water events (Hayes et al. 2016). While wildfires are unpredictable, one essential tool in limiting their intensity is to reduce vegetation density on upland slopes. The use of sustainable forestry practices to mitigate the potential impacts of high intensity wildfire on aquatic resources should be considered as a conservation measure for FYLF. It would be short-sighted to identify sustainable forestry practices as a threat under the current regulatory framework, since potential forestry related impacts are mitigated through the THP process, while at the same time these forestry activities can lead to beneficial or restorative effects for FYLF.

Bevers et al. (2004) estimated that for fuel modifications to effectively support fire suppression activities, approximately 54-88% of the landscape would need to receive fuel treatments (sustainable forestry practices). Because of the deleterious effects of high intensity fire, reducing fire severity should be a conservation goal of any listing action. With this in mind sustainable forestry practices should be viewed as a conservation action not a threat to the FYLF.

Sierra Pacific Industries believes the solution for ensuring the continued existence of FYLF in California is maintaining the hydrologic function of the streams and rivers downstream of water impoundments. We believe endangered species efforts should be focused on foothill areas generally below forested lands where marginally functioning populations of FYLF occur. We also encourage the implementation of sustainable forestry practices that reduce the risk of high intensity fires in a meaningful way.

Sincerely,

Cedric Twight
Regulatory Affairs Manager
Sierra Pacific Industries

Cc California Fish and Game Commission

References:

Bevers, M. J. Hof and P.N. Omi. 2004. Random location of fuel treatments in wildland community interfaces: a percolation approach. Canadian Journal of Forest Research. Vol. 34, No. 1: pp. 164-17. https://doi.org/10.1139/x03-204.

Bourque, R.M. 2008. Spatial Ecology of an Inland Population of the Foothill Yellow-legged Frog (Rana boylii) in Tehama County, California. Master's Thesis. Humboldt State University, Arcata, CA.

http://www.water.ca.gov/damsafety/damlisting/index.cfm. Accessed August 31, 2017.

Harrington, Jim, DFG Projects Leader/Water Quality Biologist, PowerPoint presentation titled "2012 Biological Assessment Overview." slide 49. Mr. Harrington's PowerPoint is posted on the Monitoring Study Group's Archives website at: http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_archived_documents/.

Hayes, Marc P.; Wheeler, Clara A.; Lind, Amy J.; Green, Gregory A.; Macfarlane, Diane C., tech. coords. 2016. Foothill yellow-legged frog conservation assessment in California. Gen. Tech. Rep. PSW-GTR-248. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 193 p.

Kupferberg, S. A. Lind, J. Mount, and S. Yarnell. 2008. Pulsed Flow Effects on the Foothill Yellow Legged Frog (Rana boylii): Integration of Empirical, Experimental and Hydrodynamic Modeling Approaches. First Year Interim Report. California Energy Commission, PIER Energy Related Environmental Research Program. CEC-500-2007-119.

Kupferberg, Sarah; Alessandro Catenazzi; Mary Power. (University of California, Berkeley). 2011. The Importance of Water Temperature and Algal Assemblage for Frog Conservation in Northern California Rivers with Hydroelectric Projects. California Energy Commission. Publication number: CEC-500-2014-033.

Kupferberg, S.J.; Palen, W.J.; Lind, A.J.; Bobzien, S.; Catenazzi, A.; Drennan, J.; Power, M.E. 2012. Effects of flow regimes altered by dams on survival, population declines, and range-wide losses of California river-breeding frogs. Conservation Biology. 26: 513–524.

Nussbaum, R. A.; Brodie, E.D. Jr.; Storm, R.M. 1983. Amphibians and reptiles of the Pacific Northwest. The University Press of Idaho, Moscow, Idaho, USA.

Rombough, C. J. 2006. Wintering habitat use by juvenile foothill yellow-legged frogs (Rana boylii): the importance of seeps. Northwestern Naturalist 87:159. [abstract]

Mazor, R. D., P. R. Ode, A. C. Rehn, M. Engeln, T. Boyle, E. Fintel, S. Verbrugge, and C. Yang. 2015. The California Stream Condition Index (CSCI): Interim instructions for calculating scores using GIS and R. SCCWRP Technical Report #883. SWAMP-SOP-2015-0004.

Rehn, A. C., R. D. Mazor, and P. R. Ode. 2015. The California Stream Condition Index (CSCI): A New Statewide Biological Scoring Tool for Assessing the Health of Freshwater Streams. SWAMP Technical Memorandum. SWAMP-TM-2015-0002.

https://www.epa.gov/national-aquatic-resource-surveys/indicators-benthic-macroinvertebrates. Accessed August 31, 2017.

Wheeler, C.A., J.B. Bettaso, D.T. Ashton and H.H. Welsh, Jr. 2015. Effects of Water Temperature on Breeding Phenology, Growth, and Metamorphosis of Foothill Yellow-legged Frogs (Rana boylii): A Case Study of the Regulated Mainstem and Unregulated Tributaries of California's Trinity River. River Research and Applications 31:1276-1286.

Patterson, Laura@Wildlife

From:	Vibeke Figueroa
Sent:	Friday, September 1, 2017 9:57 AM
To:	Wildlife Management
Cc:	Andy Fecko; bstorey@placer.ca.gov
Subject:	Letter from PCWA and Placer County Regarding the Foothill Yellow-Legged Frog
Attachments:	Foothill Yellow-Legged Frog.pdf

Dear Ms. Patterson:

Please find the attached letter from PCWA and Placer County with the subject: foothill yellow-legged frog.

Thank you,

Vibeke Figueroa
Administrative Aide
Placer County Water Agency
Resource Development
TEL: (530) 823-4973

PCWA
water • energy • stewardship

PCWA
water • energy • stewardship

Placer County
CALIFORNIA

September 1, 2017

VIA EMAIL TO: Wildlifemgt@wildlife.ca.gov

California Department of Fish and Wildlife
Attention: Laura Patterson
1812 9th Street
Sacramento, CA 95811

SUBJECT: Foothill Yellow-Legged Frog

Dear Ms. Patterson:

The Placer County Water Agency (PCWA or Agency) owns and operates the Middle Fork American River Project (MFP), a multi-purpose water supply and hydro-electric development that was constructed by the people of Placer County to secure the water rights and resources necessary to provide for economic development within the county.

The Agency, like many other hydro-electric facility owners in the Sierra, recently completed a Federal Energy Regulatory Commission process to renew our operating license for the MFP. During this eight year long process, the Agency and its business partner the County of Placer spent a considerable amount of time, money and effort to study and protect the Foothill Yellow-legged frog. While this species has seen declines across much of its endemic range, it is locally abundant in the Rubicon and Middle Fork American River watersheds.

The Agency believes that three factors weigh against the immediate listing of the Foothill Yellow-legged frog under California endangered species act protection:

1. While some local populations have been studied extensively, like those in the American River watershed, other systems have received far less attention. We believe more study is warranted in watersheds statewide before a listing is recommended.

2. Many watersheds in the state that have hydro-electric projects present are being re-managed for the benefit of frogs. Specific management measures that decrease flow fluctuations during critical breeding and tadpole development stages that will benefit

frog reproduction and survival have been ordered by state and federal agencies in FERC relicensing proceedings. Many of these measures have only recently been operationalized, and require time and monitoring to assess their effectiveness. We suggest an intensive five year monitoring period beginning in 2018 (which most FERC licensees have agreed to undertake) in order to better understand how new license conditions will benefit frog populations.

3. The recent moratorium placed on suction dredging in California's streams will likely have a positive impact on frog populations. During the intensive study and monitoring period we recommend, an assessment can be made regarding the effectiveness of these new limitations.

Overall, we believe existing and forthcoming management actions should be given time to become operational and mature before a new regulatory process is undertaken. The sum total of upcoming management actions will positively benefit the species, and may make a State listing moot.

Sincerely,

PLACER COUNTY WATER AGENCY

Einar Maisch
General Manager

PLACER COUNTY

David Boesch
County Executive Officer

From: Cedric Twight
Sent: Tuesday, September 5, 2017 2:09 PM
To: Patterson, Laura@Wildlife
Subject: FW: Yellow Legged Frogs Information
Attachments: 5BCRP_Chapter_5_Cons_Stgy_FPD.pdf

Hello Laura,

I got this back from Butte County Planner Dan Breedon, I know its "late" but could be a useful trail to follow (And yes, I'm not complaining ☺). The attached document references occurrences in Butte county on pg. 5-104. The text on 5-104 also references "Appendix A" which shows the "Distribution and extent (areal or linear) of each covered species' modeled habitat located within the Plan Area (Appendix A; Table 5–4, Existing Extent Modeled Covered Species Habitat Types and Covered Plant Species Occurrences within CAZs and UPAs [see separate files])." http://www.buttehcp.com/BRCP-Documents/Formal-Public-Draft-EISEIR/index.html
The link will get you to Appendix A.

I hope this helps. Are there other Counties with HCP? Might be a treasure trove of information.
Good Luck. Cedric

From: Breedon, Dan
Sent: Tuesday, September 05, 2017 11:16 AM
To: Cedric Twight
Subject: Yellow Legged Frogs

Cedric,

Sorry I have been a bit backlogged. Got your message. I don't have any experience with this particular species. You may wish to speak with Chris Devine ad the Butte County Association of Governments. Chris is heading up the Butte Regional Conservation Plan http://www.buttehcp.com/index.html and may have some information to share.

You may want to check out the Conservation Strategy from the BRCP (attached, see page 5-104).

Dan Breedon, AICP, Principal Planner
Department of Development Services
7 County Center Drive, Oroville, CA 95965

APPENDIX E

External Peer Review Solicitation Letters

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Wildlife Branch
P.O. Box 944209
Sacramento, CA 94244-2090
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

May 21, 2019

Sarah J. Kupferberg, Ph.D.
Independent Consultant
Questa Engineering
818 Mendocino Avenue
Berkeley, CA 94707
skupferberg@gmail.com

Dear Dr. Kupferberg:

RE: FOOTHILL YELLOW-LEGGED FROG (*RANA BOYLII*)
DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife's (Department) Draft Status Review of the Foothill Yellow-legged Frog (*Rana boylii*). A copy of this report, dated May 21, 2019, is enclosed for your use in that review. The Department seeks your expert analysis regarding the scientific validity of the report and its assessment of the status of the Foothill Yellow-legged Frog in California. **The Department would appreciate receiving your peer review input on or before June 21, 2019**.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under the California Endangered Species Act (CESA). As you may know, the Commission, as a constitutionally established entity distinct from the Department, exercises exclusive statutory authority under CESA to add species to the state lists of endangered and threatened species (Fish & G. Code, § 2070). The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to use the best scientific information available to make related recommendations to the Commission (Fish & G. Code, § 2074.6).

The Commission first received the "Petition to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened" (Petition) on December 14, 2016 and published a formal notice of receipt on January 20, 2017 (Cal. Reg. Notice Register 2017, No. 3-Z, p. 46). On April 17, 2017, the Department provided the Commission with its "Evaluation of the Petition from the Center for Biological Diversity to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened under the California Endangered Species Act" to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5

& 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e).). Focusing on the information available to it relating to each of the relevant categories, the Department recommended to the Commission that the Petition be accepted.

The draft report forwarded to you today reflects the Department's effort to identify and analyze available scientific information regarding the status of Foothill Yellow-legged Frog in California. An endangered species is defined as "a native species or subspecies...which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies...that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067). At this time, the Department suggests listing the species under CESA is warranted for five of six recently described genetic clades based on the available science. The Department proposes to recommend endangered status for the South Coast, Central Coast, and Southern Sierra clades; threatened status for the Northern Sierra and Feather River clades; and "not warranted at this time" for the North Coast clade. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendations to the Commission as required by the Fish and Game Code.

Because of the importance of your effort, we ask you to focus your review on the scientific information regarding the status of Foothill Yellow-legged Frog in California. As with our own effort to date, your peer review of the science and analysis regarding each of the listing factors prescribed in CESA (Cal. Code Regs., Tit. 14, § 670.1(i)(1)(A)) (i.e., present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important.

Please note the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "Track Changes" in Microsoft Word, or provide comments in list form by page number, section header, and paragraph.

Please submit your comments electronically to Laura Patterson, Senior Environmental Scientist (Specialist) with the Wildlife Branch at Laura.Patterson@wildlife.ca.gov or at the address in the letterhead above. If you have any questions, you may reach Laura Patterson by phone at (916) 341-6981.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Kari Lewis, Chief
Wildlife Branch
Department of Fish and Wildlife

Enclosure

ec: **Department of Fish and Wildlife**

Stafford Lehr, Deputy Director
Wildlife and Fisheries Division
Stafford.Lehr@wildlife.ca.gov

Kevin Shaffer, Chief
Fisheries Branch
Kevin.Shaffer@wildlife.ca.gov

Erin Chappell, Wildlife Branch
Nongame Program Manager
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Laura Patterson, Wildlife Branch
Senior Environmental Scientist (Specialist)
Laura.Patterson@wildlife.ca.gov

State of California – Natural Resources Agency
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P.O. Box 944209
Sacramento, CA 94244-2090
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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

May 21, 2019

Amy J. Lind, Ph.D.
Hydroelectric Coordinator
Tahoe and Plumas National Forests
USDA Forest Service
631 Coyote St.
Nevada City, CA 95959
alind@fs.fed.us

Dear Dr. Lind:

RE: FOOTHILL YELLOW-LEGGED FROG (*RANA BOYLII*)
DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife's (Department) Draft Status Review of the Foothill Yellow-legged Frog (*Rana boylii*). A copy of this report, dated May 21, 2019, is enclosed for your use in that review. The Department seeks your expert analysis regarding the scientific validity of the report and its assessment of the status of the Foothill Yellow-legged Frog in California. **The Department would appreciate receiving your peer review input on or before June 21, 2019**.

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& 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e).). Focusing on the information available to it relating to each of the relevant categories, the Department recommended to the Commission that the Petition be accepted.

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Kari Lewis, Chief
Wildlife Branch
Department of Fish and Wildlife

Enclosure

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State of California – Natural Resources Agency
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P.O. Box 944209
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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

May 21, 2019

Jimmy A. McGuire, Ph.D.
Professor, Department of Integrative Biology
Curator of Herpetology, Museum of Vertebrate Zoology
3101 Valley Life Sciences Building
University of California
Berkeley, CA 94720
mcguirej@berkeley.edu

Dear Dr. McGuire:

RE: FOOTHILL YELLOW-LEGGED FROG (*RANA BOYLII*)
DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

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& 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e).). Focusing on the information available to it relating to each of the relevant categories, the Department recommended to the Commission that the Petition be accepted.

The draft report forwarded to you today reflects the Department's effort to identify and analyze available scientific information regarding the status of Foothill Yellow-legged Frog in California. An endangered species is defined as "a native species or subspecies...which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies...that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067). At this time, the Department suggests listing the species under CESA is warranted for five of six recently described genetic clades based on the available science. The Department proposes to recommend endangered status for the South Coast, Central Coast, and Southern Sierra clades; threatened status for the Northern Sierra and Feather River clades; and "not warranted at this time" for the North Coast clade. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendations to the Commission as required by the Fish and Game Code.

Because of the importance of your effort, we ask you to focus your review on the scientific information regarding the status of Foothill Yellow-legged Frog in California. As with our own effort to date, your peer review of the science and analysis regarding each of the listing factors prescribed in CESA (Cal. Code Regs., Tit. 14, § 670.1(i)(1)(A)) (i.e., present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important.

Please note the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "Track Changes" in Microsoft Word, or provide comments in list form by page number, section header, and paragraph.

Please submit your comments electronically to Laura Patterson, Senior Environmental Scientist (Specialist) with the Wildlife Branch at Laura.Patterson@wildlife.ca.gov or at the address in the letterhead above. If you have any questions, you may reach Laura Patterson by phone at (916) 341-6981.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Kari Lewis, Chief
Wildlife Branch
Department of Fish and Wildlife

Enclosure

ec: **Department of Fish and Wildlife**

Stafford Lehr, Deputy Director
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State of California – Natural Resources Agency
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Wildlife Branch
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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

May 21, 2019

Ryan A. Peek, Ph.D.
Post-doctoral Researcher
Center for Watershed Sciences
One Shields Avenue
University of California
Davis, CA 95616
rapeek@ucdavis.edu

Dear Dr. Peek:

RE: FOOTHILL YELLOW-LEGGED FROG (*RANA BOYLII*)
DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife's (Department) Draft Status Review of the Foothill Yellow-legged Frog (*Rana boylii*). A copy of this report, dated May 21, 2019, is enclosed for your use in that review. The Department seeks your expert analysis regarding the scientific validity of the report and its assessment of the status of the Foothill Yellow-legged Frog in California. **The Department would appreciate receiving your peer review input on or before June 21, 2019**.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under the California Endangered Species Act (CESA). As you may know, the Commission, as a constitutionally established entity distinct from the Department, exercises exclusive statutory authority under CESA to add species to the state lists of endangered and threatened species (Fish & G. Code, § 2070). The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to use the best scientific information available to make related recommendations to the Commission (Fish & G. Code, § 2074.6).

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Sincerely,

Kari Lewis, Chief
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Laura.Patterson@wildlife.ca.gov

APPENDIX F

External Peer Review Comments

Patterson, Laura@Wildlife

From: Sarah Kupferberg <skupferberg@gmail.com>
Sent: Wednesday, June 19, 2019 5:43 PM
To: Patterson, Laura@Wildlife
Subject: Re: Peer Review Request: Foothill Yellow-legged Frog Status Review
Attachments: DRAFT FYLF Status Review-2019.05.21 (kupferberg comments) (AutoRecovered).docx; review kupferberg.docx

Hello Laura,
Please find attached my comments on the Draft Status Review and a marked up version of the manuscript using track changes that includes minor edits to the text.
Thank you for giving me the opportunity to be involved in such an important process.
I am very impressed with how thorough the document is. You may not have set out to provide an exhaustive review of the scientific literature, but I think that is what you have achieved. A job well done!
The vast majority of my specific comments are suggestions, not corrections, take them or leave them.
Kind Regards,
Sarah

On Wed, May 22, 2019 at 10:22 AM Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov> wrote:

> Great, thanks! If you feel like you're running out of time, let me know, and I can help you prioritize which sections to try to get to.
>
> **From:** Sarah Kupferberg <skupferberg@gmail.com>
> **Sent:** Wednesday, May 22, 2019 10:20 AM
> **To:** Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov>
> **Cc:** Sarah Kupferberg <skupferberg@berkeley.edu>
> **Subject:** Re: Peer Review Request: Foothill Yellow-legged Frog Status Review
>
> Hello Laura-
>
> I just returned from the Eel River and received your email. The timeline of completing my review by June 21 seems quite doable.
>
> Regards,
>
> Sarah
>
> On Tue, May 21, 2019 at 1:52 PM Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov> wrote:
>
>> Good afternoon, Dr. Kupferberg,

Thanks for your patience. We had a couple of loose ends to tie up. Please see the attached letter and draft status review. If you have any questions or concerns with the timeline, please let me know.

Will you please respond to this email to confirm you received it?

Thanks again,

Laura

From: Sarah Kupferberg <skupferberg@gmail.com>
Sent: Tuesday, April 2, 2019 10:07 PM
To: Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov>
Cc: Sarah Kupferberg <skupferberg@berkeley.edu>
Subject: Re: Peer Review Request: Foothill Yellow-legged Frog Status Review

Hello Laura,

I would be happy to participate and help with the review process. I do not have a financial conflict of interest. I will be in and out of the field during that time period, doing my annual breeding surveys but will do my best to ensure rapid turn around.

Regards,

Sarah

On Tue, Apr 2, 2019, 3:25 PM Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov> wrote:

> Dear Dr. Kupferberg,
>
> The Fish and Game Commission (Commission) was petitioned to list the Foothill Yellow-legged Frog as threatened under the California Endangered Species Act (CESA) by the Center for Biological Diversity in December 2016. The California Department of Fish and Wildlife (Department) is tasked with writing a status review and providing a recommendation to the Commission on whether or not the best scientific information available supports the petitioner's position that listing is warranted. Part of the status review process is external peer review of the draft status review.

I am contacting you as a Foothill Yellow-legged Frog subject matter expert to request your participation in the peer review process. The Department expects the draft will be ready on for distribution to peer reviewers on or around May 17th. We would ask that you focus your review on the scientific information available regarding the status of Foothill Yellow-legged Frogs in California. Your peer review of the science and analysis regarding each of the listing factors prescribed in CESA (i.e., present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) is particularly valuable. We request that comments be submitted on or before one month from the date of receipt (on or around June 17th).

In addition, per the Department's Peer Review Policy (Department Bulletin 2017-03), I must ensure that you have no financial or other conflict of interest with the outcome or implications of the peer reviewed product.

Please respond to whether you are willing and able to participate in this important part of the listing determination process by Thursday April 11th.

Thank you for your consideration,

Laura

General Comments:

The draft STATUS REVIEW OF THE FOOTHILL YELLOW-LEGGED FROG (*Rana boylii*) IN CALIFORNIA is a scientifically sound and well-written document that very clearly summarizes the natural history of the species and outlines the current and future threats to its persistence throughout the state. The organization and progression of information and ideas are logical and straightforward in presentation. Complex concepts in ecology and population genetics are defined, and the needed background information on environmental change anticipated during an uncertain climate future is well summarized. The document accurately synthesizes knowledge from the scientific literature, reports, conference presentations, with observations from experienced field biologists and regulators who have been working with *Rana boylii* for many years. I have no criticisms with respect to presentation or interpretation of research and scientific information in the document. I have made minor suggestions with respect to wording and noted a few typographical errors in the body of the text. Overall, I find the background information sections titled BIOLOGY AND ECOLOGY, STATUS AND TRENDS IN CALIFORNIA, and FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE, to be comprehensive and insightful. The section covering the threats, SUMMARY OF LISTING FACTORS, is consistent with my knowledge of the species garnered over the past 25 years of field work and the scientific literature. My own research is correctly and accurately represented.

While environmental policy is not my academic area of expertise, I have observed firsthand the effects of water management and dam operations on *Rana boylii*, so am providing some opinions. These are offered as suggestions, not as needed changes. I think that the section entitled “EXISTING MANAGEMENT” could include more information about the shortcomings of the existing laws that contribute to the need for greater protection of *Rana boylii* under the California Endangered Species Act, CESA. One example is when a utility no longer wants to operate a dam and the dam becomes an ‘orphaned dam’ under FERC. Given the declining profitability of hydropower projects (especially for older dams/reservoirs) and the bankruptcy of PG&E, this may be a growing issue that dams may be operated on a somewhat *ad hoc* basis (i.e. not relicensed). During the limbo period while funds are raised for dam removal or a transfer to a different utility occurs, the needed studies to determine effects of operations on frogs (or other wildlife) don’t happen to inform any kind of adaptive management. I am not sure what laws govern the transfers to Dam Removal entities, such as happened with the multiple dams on the Klamath River that are now slated for removal. For example dam operations may proceed in ways known to be harmful to *Rana boylii*, such as pulsed flows after egg-laying has commenced, as is currently the case of Scott Dam on the Eel River now that the Potter Valley Project is an ‘orphan’.

With respect to the section titled LISTING RECOMMENDATION, I find that parsing designation by geographic region / clade is justified by the data presented. Because there are marked differences in the number of known populations, the range of populations’ sizes from sparse to robust, and the level of genetic differentiation across the state, I concur with the statement that listing “by genetic clade is the prudent approach due to the disparate degrees of imperilment”. I agree with the designation of ‘endangered’ for the West/Central Coast, the South/Southwest Coast, and the Southern Sierra clade because there are several risk factors at play, so few known populations in these regions, the remaining populations are small, and they are genetically distinct. I also agree with a special designation for the Feather, given the uniqueness of this clade and the extensive fragmentation due to the development of hydropower projects in the area.

In comparison, the abundance of large populations in the extended geographic area of the North Coast indicates that this clade is not at immediate risk of extirpation. Consequently, the decision to maintain the present designation of Species of Special Concern is reasonable. This strategy does have a drawback at the perimeter of such a large geographic region, where populations are sparser and disconnected. The option for a greater level of protection is lost. I suppose this trade-off is unavoidable, but I am concerned about the fate of populations in peripheral places like streams on Mt. Tamalpais in Marin County and the McCloud River in Shasta / Siskyou counties. My hope is that the efforts being made in Marin County to protect the populations there will continue without an elevation of the listing designation. The docent program and habitat restoration (e.g. canopy thinning) undertaken by the Marin Municipal Water District are excellent examples of stewardship.

Unfortunately, some utilities are less transparent and responsible than others. A book could be written about the ways in which the San Francisco Public Utilities Commission operates its facilities in the Alameda Creek watershed without making modifications or changes to protect the frogs and exploiting weaknesses in the regulatory framework. Over $40 million dollars were spent to build the fish passage structure mentioned on p. 68, while funds have yet to be allocated to improve habitat or conditions for frogs as was called for in the EIR for the Calaveras Dam replacement project. Furthermore, studies conducted on frogs that would have been useful in the preparation of this Status Review and that predicted negative impacts were never disseminated or made public, only retrievable through Public Records Act requests. The fish passage structure was built upstream of a natural barrier to fish passage, the steep bedrock canyon reach of Alameda Creek known as Little Yosemite. In order for steelhead to reach the large concrete structure, the frog breeding sites in Little Yosemite would have to be destroyed by construction of weirs and altering the water surface elevations of pools. SFPUC tried to exploit loopholes in the CEQA process by making a negative declaration of impact for the Little Yosemite project.

Another chapter in such a book would cover how the protected status / and unrealistic recovery plan for one species can endanger another. I am not sure how it would be incorporated into this document (and perhaps it is more appropriate during the public comment period), but an important question is how will biological conflicts between anadromous fish and frogs and jurisdictional conflicts between agencies (e.g. NMFS and CDFW) be resolved when salmonids are not the only endangered species in a river. Because *Rana boylii* occupy whole dendritic networks of streams, and their life cycle is so entwined with the hydrologic an geomorphic processes of fluvial habitats, an added benefit of protecting them is that there will likely be more thoughtful consideration made when multiple riverine species require accommodation in the same reach. I believe that protection of *Rana boylii* recommended in this Status Review will eventually lead to a more holistic management philosophy for California rivers and streams in the future.

<u>Specific comments:</u>

1. p. vi. The illustrations of Kevin Wiseman's pen and ink drawing and Isaac Chellman's photograph are beautiful – nice choices. I am curious where the frog is from, I have never seen one so overall golden in color. Maybe include the general location when giving credit for the photo?

2. **p. 5** This is trivial, but maybe worth mentioning that for a period of time species name was spelled *boylei*?

3. p. 10 Figure 4. For this figure's legend I think there are a couple of pieces of information that need adding. First, please specify what the numbers are next to each symbol. Is it numbers of pairs of individuals at the river distance on the x axis within the same river? Also I am assuming that these are all data from various rivers within the American River drainage. If not please include info from Ryan's thesis that would specify.

4. Table of predators. If you would like to add another pers comm. observation I have seen otters (a mom and a couple of her young) eating tadpoles on the Angelo Reserve where the tadpoles were concentrated in a side pool.

5. Figures 8, 9. There are very few blue dots (2010-present) for San Benito County, and several extirpated populations (black squares). So, out of curiosity I looked on i-naturalist and there were several. Problem is that the platform obscures the location / coordinates, so it is hard to know how the recent sightings jive with the ones in this map. Do you think that there is a way to reach out to the amateur naturalists to determine where the extant populations are in the region sparsely occupied by the West/Central Coast clade?

6. p. 26. Moraga Creek observation. This record came under scrutiny / was questioned when I was conducting surveys for East Bay Regional Park District not too many miles from Moraga Creek for a stream daylighting project they are planning for Alder and Leatherwood Cks, tributaries to San Leandro Creek. Marcia Grefsrud was going to reach out to the person (Jeff Drier) who made the sighting to see if he had photos. Not sure what she found out.

7. p. 26 Coyote Creek news. In spring 2019 I conducted breeding surveys in Coyote Creek in Henry Coe State Park covering a 3 km reach (including the pools where I found dead frogs fall of 2018). Over two visits I counted 80 clutches (ca. 26/km), but there were some already hatched tadpoles on the first visit and it was difficult to attribute how many clutches worth they were, so this count is an underestimate.

My search area was upstream of the reaches covered by Earl Gonsolin in 2004 and 2005, so comparisons are not exact. I checked Table 1 of his Master's thesis and the densities he recorded were

Lower Reach 2004=17.2, 2005=24.8

Upper Reach 2004= 12.6, 2005=17.9

So, in spite of the die-off I observed last fall, the reproductive output in 2019 doesn't necessarily indicate a drastic difference to the density of breeding adults relative to 15 years ago. However, the loss of juvenile frogs may become apparent in the future when that cohort would have reached breeding age.

8. p. 32. Surveys around / near Yosemite. SFPUC has surveyed the Tuolumne River, near Early Intake, which is not too many river miles downstream of the border with Yosemite National Park (in Stanislaus Natl forest). I received an email dated 6/26/18 from Alan Striegle reporting one clutch.

9. p. 54. Road effects. The pattern of fords / vehicle stream crossings being at breeding sites is something I have seen in many locations including in Mendocino National Forest on the Rice Fork Eel. I think this is also the case with trails – I think there is a popular mountain bike trail on MMWD land that crosses a stream at a breeding site.

10. p. 57. Channel modifications associated with temporary swimming holes. In public places, parks, etc. I see this all the time in the parts of Alameda Creek open to the public within the park. People are constantly building little dams across the channel with whatever cobbles and small boulders are available to create better swimming spots.

11. p. 59 paragraph starting with 'Rapidly receding…' I think this paragraph needs a more general topic sentence, because it covers other effects of drought beyond stranding. Maybe a sentence stating that the effects of droughts, and a 'whiplash' climate which vacillates between extremes of droughts and floods, can create a complex mix of positive and negative effects on FYLF. At Coyote Creek I wonder if part of the Bd outbreak dynamics were driven by the high densities associated with stream drying, which would be consistent with the effects of density seen in the Alameda Ck Bd outbreak.

12. p. 59. In reference to the recent drought, you may want to cite Bogan et al 2019 regarding the abundance of FYLF in remnant pools at Coyote Ck.
M. T. Bogan, R. A. Leidy, L. Neuhaus, C. J. Hernandez, S. M. Carlson. 2019. Biodiversity value of remnant pools in an intermittent stream during the great California drought. Aquatic Conservation https://doi.org/10.1002/aqc.3109

13. p. 60 Although salvage logging is discussed further on, it might be worth mentioning in this paragraph when bringing up the topic of erosion post-fire.

14. p. 62. I suggest adding a summary paragraph before moving on to climate change to pull together the implications of all the sources of mortality reviewed in the previous sections and segue to the next section in which the modeled increase in droughts is presented. When considered cumulatively, the sources of mortality that could lead to local extirpations are problematic because the process of re-colonization is short circuited when populations are un-naturally isolated and distant from one another. In many cases the drier and less predictable future, there will likely be no, or only very small source populations that could produce dispersers to found new populations after an extirpation. The management implication of the human modified landscape is that recolonization is going to depend on assisted migration. Generally, there is evidence to support the idea that FYLF are disturbance adapted, having evolved through many millennia of drought and floods and fires, and likely part of their success as a species has been the ability to have rapid population increases when new populations are founded. I think that capacity bodes well for the development of a recovery plan.

15. p. 64, paragraph 3. It might be worth mentioning here the role that local geology / lithology can play in either buffering or accentuating the impact of hydrologic change on FYLF. In basins with a large degree of springs and volcanic rock (like in the Pit River drainage) base flows remain higher than one might expect. Also in places with a lot of faulting, there can be springs that maintain some presence of above ground water. In other places, increased winter flooding / precipitation may not translate into any increase in summer base flows because there is simply limited sub-surface storage. I think this perspective about the importance of rock types may be really helpful in making decisions about recovery planning, and choosing which watersheds might have high likelihood of successful re-introduction or augmentation.

Hahm, W. J., Dralle, D. N., Rempe, D. M., Bryk, A. B., Thompson, S. E., Dawson, T. E., & Dietrich, W. E. (2019). Low subsurface water storage capacity relative to annual rainfall decouples Mediterranean plant productivity and water use from rainfall variability. *Geophysical Research Letters*.

16. p. 65 paragraph 5. I think the point about fragmentation is super important and salient – is there a way to give this idea more prominence? Perhaps as a conclusion to the climate change section? I am afraid it gets buried here in the middle of the section. I think that fragmentation, in addition to thwarting a pole ward range-shift response, will limit any upslope migration within a watershed. For many larger rivers in the Sierra moving to a higher elevation is not an option, the path is blocked by dams and reservoirs.

17. p. 69, bottom. It is tricky to include all State Park lands in the umbrella of land being protected because it includes the Off Highway Vehicular Recreation Areas, which are not truly protected with respect to conserving wildlife. Also the heavy recreation allowed in other state parks can also be an issue, I am thinking about 'Reggae on the River' and other such festivals in which there is very heavy use of river side habitats.

18. p. 70 The statement that **"**a property's management does not necessarily benefit Foothill Yellow-legged Frogs" requires some examples of the types of management being referred to. A general reader might not read between the lines here.

19. p. 73 Second to last paragraph about compliance requirements of Lake and Streambed Alteration Agreements. In my experience working in Alameda Creek, it seems like there are few repercussions when an entity either violates their LSA or lets their LSA expire, yet continues to work in the stream, or affect the stream. Perhaps it is not appropriate here to delve into the problems of lack of 'teeth' for enforcing agreements, but this is one of the shortcomings of existing protections that is relevant to the need for protection under CESA.

20. p. 75 Hetch Hetchy**.** Not sure it is worth mentioning under this section on laws and the Upper Tuolumne River, but SFPUC / Modesto Irrigation District operate outside of FERC scrutiny because of the Raker Act

https://www.nps.gov/yose/blogs/remember-hetch-hetchy-the-raker-act-and-the-evolution-of-the-national-park-idea.htm

21. **p. 75.** For the Chili Bar reference I suggest naming the river reaches, some readers many not know this refers to the reach of the South Fork American River that is a popular white water boating reach with pulsed flows. I think that it is worth noting the fate of the frogs at these sites. I may not be totally up to date about the status of the populations at that at these locations, but I believe they were or have become sparse / teetering on extirpation. One could infer that despite the incorporation of best management practices into the new licenses, the effects of small population size, which are outlined so clearly on p. 69, could not be overcome through BMP's alone.

22. **p. 84**. conservation funds. Would the state listing influence IUCN red list status? I know that there are certain conservation funding opportunities tied to IUCN status. It also might be worth stating here that listing status might improve the situation with respect to interactions with National Marine Fisheries Service, which acts with a singular mission to restore anadromous salmonids in California rivers, a goal which can at times be in conflict with conservation of other native taxa.

23. **p. 87, paragraph 2.** In addition to (or maybe as a component of) habitat suitability assessment, I wonder if it would be appropriate to use surrogates for FYLF. For example could Bd and pesticide residues be assessed in treefrogs or other local amphibians? Or to assess whether hydroperiod might be adequate, surveys to determine newts' ability to successfully reach metamorphosis at the site could serve as a proxy.

24. **p. 87 bottom** – metapopulation dynamics. I think that an element of the research needed on this topic should be to identify upstream and downstream boundaries of populations, to document the conditions where densities dwindle at the periphery of a distribution. I think the difference between marginal and completely unsuitable habitat requires better distinction.

25. **p. 88** off-stream water storage. As long as these water bodies are managed so they don't create habitat for bullfrogs and non-native fish, they are a good idea.

26. p. 89 barrier removal. This is a complicated recovery action that can have unintended consequences. In some cases though, rocks / hydraulic jumps that make a barrier to fish passage may actually create habitat for FYLF, or prevent the upstream migration of non natives like crayfish. Especially in step pool morphology channels, frogs may utilize the sites that are not passable by fish. Removing the barriers could allow non natives to move upstream (Kerby, J.L., Riley, S.P., Kats, L.B. and Wilson, P., 2005. Barriers and flow as limiting factors in the spread of an invasive crayfish (*Procambarus clarkii*) in southern California streams. *Biological Conservation*, *126*(3), pp.402-409.)

27. **p. 89, enforcement**. What about utilities or governmental or state agencies that are causing harm -- How does law enforcement apply to these larger entities when they violate a law or an agreement? For example SFPUC commissioned studies to be done to be incorporated into an HCP, but then did not release the reports that documented the negative impacts to *Rana boylii* and suspended the HCP process. They received their permits and rebuilt the Calaveras Dam, but did not comply or fulfill their obligations under existing environmental law. On p. 76 where HCP's and Natural Community Conservation Plans are discussed, I find that the authorized take does not always lead to an improvement or compensation elsewhere. Who are the HCP police?

STATE OF CALIFORNIA
NATURAL RESOURCES AGENCY
DEPARTMENT OF FISH AND WILDLIFE

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF THE **FOOTHILL YELLOW-LEGGED FROG** (*Rana boylii*) IN CALIFORNIA

CHARLTON H. BONHAM, DIRECTOR
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
External Peer Review Draft

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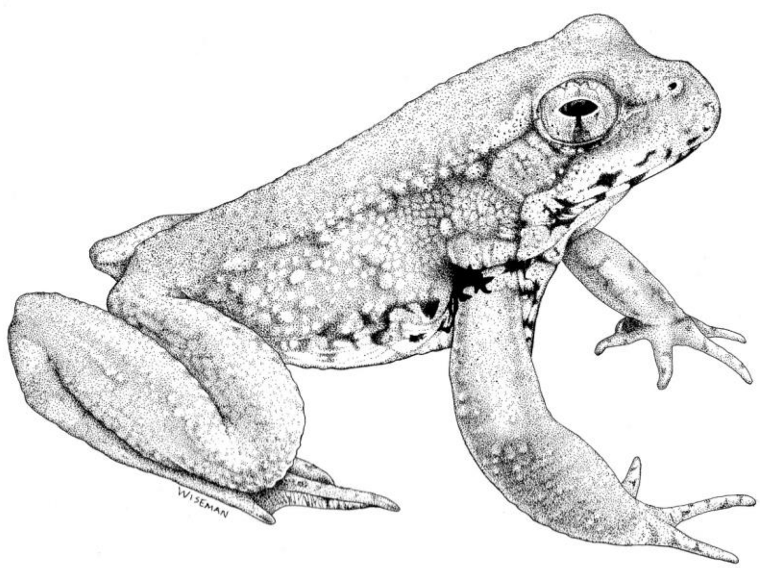

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EXECUTIVE SUMMARY

[To be completed after external peer review]

REGULATORY SETTING

Petition Evaluation Process

A petition to list the Foothill Yellow-legged Frog (*Rana boylii*) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on December 14, 2016 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on December 22, 2016 and published a formal notice of receipt of the petition on January 20, 2017 (Cal. Reg. Notice Register 2017, No. 3-Z, p. 46). A petition to list or delist a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3).

On April 17, 2017, the Department provided the Commission with its evaluation of the petition, "Evaluation of the Petition from the Center For Biological Diversity to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on June 21, 2017, in Smith River, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Foothill Yellow-legged Frog was designated a candidate species on July 7, 2017 (Cal. Reg. Notice Register 2017, No. 27-Z, p. 986).

Status Review Overview

The Commission's action designating the Foothill Yellow-legged Frog as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 21, 2018, in Sacramento, California, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

This status review report is not intended to be an exhaustive review of all published scientific literature relevant to the Foothill Yellow-legged Frog; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to the Foothill Yellow-legged Frog. This review is intended to provide the Commission with the most current information on the Foothill Yellow-legged Frog and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The status review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

Federal Endangered Species Act Review

The Foothill Yellow-legged Frog is currently under review for possible listing as threatened or endangered under the federal Endangered Species Act (ESA) in response to a July 11, 2012 petition submitted by the Center for Biological Diversity. On July 1, 2015, the U.S. Fish and Wildlife Service (USFWS) published its 90-day finding that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted and initiated a status review of the species (USFWS 2015). On March 16, 2016, the Center for Biological Diversity sued the USFWS to compel issuance of a 12-month finding on whether listing under the ESA is warranted. On August 30, 2016, the parties reached a stipulated settlement agreement that the USFWS shall publish its 12-month finding in the Federal Register on or before September 30, 2020 (*Center for Biological Diversity v. S.M.R. Jewell* (D.D.C. Aug. 30, 2016, No. 16-CV-00503)).

BIOLOGY AND ECOLOGY

Species Description and Life History

> *"In its life-history* boylii *exhibits several striking specializations which are in all probability related to the requirements of life of a stream-dwelling species"* – Tracy I. Storer, 1925

The Foothill Yellow-legged Frog is a small- to medium-sized frog; adults range from 38 to 81 mm (1.5-3.2 in) snout to urostyle length (SUL) with females attaining a larger size than males and males possessing paired internal vocal sacs (Zweifel 1955, Nussbaum et al. 1983, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs are typically gray, brown, olive, or reddish with brown-black flecking and mottling, which generally matches the substrate of the stream in which they reside (Nussbaum et al. 1983, Stebbins and McGinnis 2012). They often have a pale triangle between the eyes and snout and broad dark bars on the hind legs (Zweifel 1955, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs have a relatively squat body and granular skin, giving them a rough appearance similar to a toad, and fully webbed feet with slightly expanded toe tips (Nussbaum et al. 1983). The tympanum is also rough

and relatively small compared to congeners at around one-half the diameter of the eye (Zweifel 1955). The dorsolateral folds (glandular ridges extending from the eye area to the rump) in Foothill Yellow-legged Frogs are indistinct compared to other western North American ranids (Stebbins and McGinnis 2012). Ventrally, the abdomen is white with variable amounts of dark mottling on the chest and throat, which are unique enough to be used to identify individuals (Marlow et al. 2016). As their name suggests, the underside of their hind limbs and lower abdomen are often yellow; however, individuals with orange and red have been observed within the range of the California Red-legged Frog (*Rana draytonii*), making hindlimb coloration a poor diagnostic characteristic for this species (Jennings and Hayes 2005).

Adult females likely lay one clutch of eggs per year and may breed every year (Storer 1925, Wheeler et al. 2006). Foothill Yellow-legged Frog egg masses resemble a compact cluster of grapes approximately 45 to 90 mm (1.8-3.5 in) in diameter length-wise and contain anywhere from around 100 to over 3,000 eggs (Kupferberg et al. 2009c, Hayes et al. 2016). The individual embryos are dark brown to black with a lighter area at the vegetative pole and surrounded by three jelly envelopes that range in diameter from approximately 3.9 to 6.0 mm (0.15-0.25 in) (Storer 1925, Zweifel 1955, Hayes et al. 2016).

Foothill Yellow-legged Frog tadpoles hatch out around 7.5 mm (0.3 in) long and are a dark brown or black (Storer 1925, Zweifel 1955). They grow rapidly to 37 to 56 mm (1.5-2.2 in) and turn olive with a coarse brown mottling above and an opaque silvery color below (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012). Their eyes are positioned dorsally when viewed from above (i.e., within the outline of the head), and their mouths are large, downward-oriented, and suction-like with several tooth rows (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012, Hayes et al. 2016). Foothill Yellow-legged Frogs metamorphose at around 14-17 mm (0.55-0.67 in) SUL (Fellers 2005). Sexual maturity is attained at around 30-40 mm (1.2-1.6 in) SUL and 1-2 years for males and around 40-50 mm (1.6-2.0 in) SUL and 3 years for females, although in some populations this has been accelerated by a year (Zweifel 1955, Kupferberg et al. 2009c, Breedveld and Ellis 2018). During the breeding season, males can be distinguished from females by the presence of nuptial pads (swollen darkened thumb bases that aid in holding females during amplexus) and calling, which frequently occurs underwater but sometimes from the surface (MacTague and Northen 1993, Stebbins 2003, Silver 2017).

The reported lifespan of Foothill Yellow-legged Frogs varies widely by study. Storer (1925) and Van Wagner (1996) estimated a maximum age of 2 years for both sexes and the vast majority of the population. Breedveld and Ellis (2018) calculated the typical lifespan of males at 3-4 years and 5-6 years for females. Bourque (2008), using skeletochronology, found an individual over 7 years old and a mean age of 4.7 and 3.6 years for males and females, respectively. Drennan et al. (2015) estimated maximum age at 13 years for both sexes in a Sierra Nevada population and 12 for males and 11 for females in a Coast Range population.

Range and Distribution

Foothill Yellow-legged Frogs historically ranged from the Willamette River drainage in Oregon west of the Sierra-Cascade crest to at least the San Gabriel River drainage in Los Angeles County, California (Figure 1; Zweifel 1955, Stebbins 2003). In addition, a disjunct population was reported from 2,040 m

Figure 1. Foothill Yellow-legged Frog historical range (adapted from CWHR, Loomis [1965], Nussbaum et al. [1983])

(6,700 ft) in the Sierra San Pedro Mártir, Baja California Norte, México (Loomis 1965). In California, the species occupies foothill and mountain streams in the Klamath, Cascade, Sutter Buttes, Coast, Sierra Nevada, and Transverse ranges from sea level to 1,940 m (6,400 ft), but generally below 1,525 m (5,000 ft) (Hemphill 1952, Nussbaum et al. 1983, Stebbins 2003, Olson et al. 2016). Zweifel (1955) considered Foothill Yellow-legged Frogs to be present and abundant throughout their range where streams possessed suitable habitat.

Taxonomy and Phylogeny

Foothill Yellow-legged Frogs belong to the family Ranidae (true frogs), which inhabits every continent except Antarctica and contains more than 700 species (Stebbins 2003). The species was first described by Baird (1854) as *Rana boylii*. After substantial taxonomic uncertainty with respect to its relationship to other ranids (frogs in the family Ranidae) and several name changes over the next century, the Foothill Yellow-legged Frog (*R. boylii* with no subspecific epithet) was eventually recognized as a distinct species again by Zweifel (1955, 1968). The phylogenetic relationships among the western North American *Rana* spp. have been revised several times and are still not entirely resolved (Thomson et al. 2016). The Foothill Yellow-legged Frog was previously thought to be most closely related to the higher elevation Mountain Yellow-legged Frog (*R. muscosa*) (Zweifel 1955; Green 1986a,b). However, genetic analyses undertaken by Macey et al. (2001) and Hillis and Wilcox (2005) suggest they are more closely related to Oregon Spotted Frogs (*R. pretiosa*) and Columbia Spotted Frogs (*R. luteiventris*), respectively.

Population Structure and Genetic Diversity

Foothill Yellow-legged Frog populations exhibit varying levels of partitioning and genetic diversity ~~at different~~depending on the spatial ~~scales~~scale of comparison. At the coarse landscape level across the species' extant range, McCartney-Melstad et al. (2018) recovered five deeply divergent, geographically cohesive, genetic clades (Figure 2), while Peek (2018) recovered six (Figure 3). Genetic divergence is the process of speciation; it is a measure of the number of mutations accumulated by populations over time from a shared ancestor that differentiate them from the other populations in a species. When genetic divergence among clades is large enough, it can be used as a tool to define new species or subspecies.

The geographic breaks among the five clades were similar between the studies, but Peek (2018) identified a separate deeply divergent genetic clade in the Feather River watershed that is distinct from the rest of the northern Sierra Nevada clade. The five clades ~~the two studies shared~~(common to both studies) include the following [Note: naming conventions follow McCartney-Melstad et al. (2018) and Peek (2018)]:

(1) Northwest/North Coast: north of San Francisco Bay in the Coast Ranges and east into Tehama County;
(2) Northeast/Northern Sierra: northern El Dorado County (North Fork American River watershed, includes Middle Fork) and north in the Sierra Nevada to southern Plumas County (Upper Yuba River watershed);

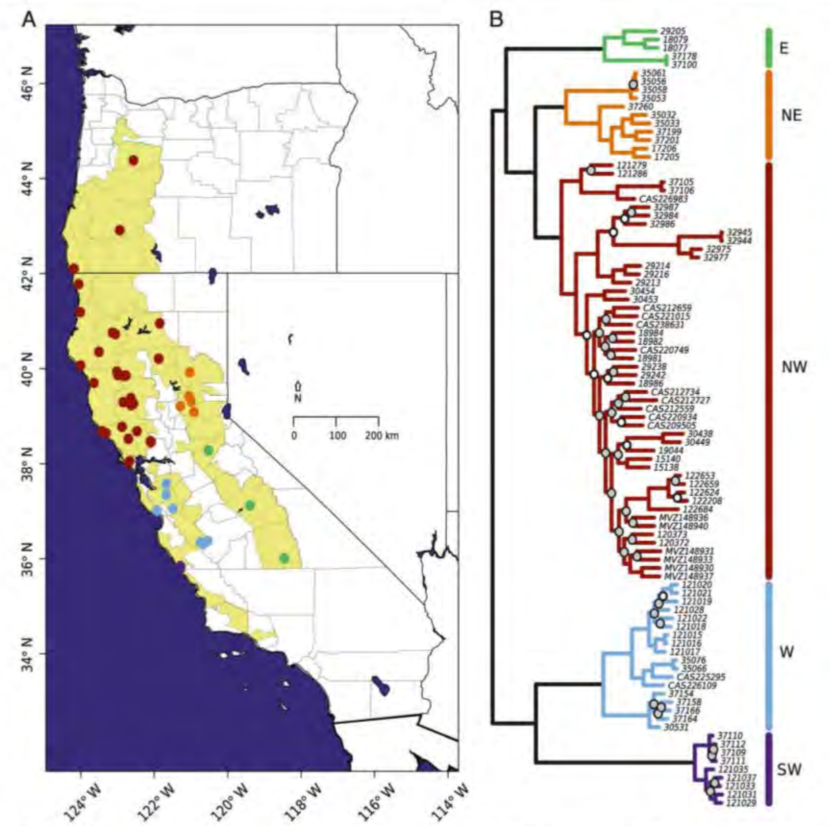

Fig. 1 a Map of *Rana boylii* sample localities. County outlines are shown within California and Oregon. Light yellow indicates the IUCN range map of *R. boylii*, excluding a small disjunct population at Sierra San Pedro Martir, Baja California, Mexico. Dots are colored by major grouping as determined in the **b** RAxML phylogeny, with midpoint rooting. Nodes without dots received >95% bootstrap support, those with white dots received <95% but greater than or equal to 75% bootstrap support, while nodes with gray dots received <75% bootstrap support

Figure 2. Foothill Yellow-legged Frog clades by McCartney-Melstad et al. (2018)

(3) East/Southern Sierra: El Dorado County (South Fork American River watershed) and south in the Sierra Nevada [no samples from Amador County were tested, but they would most likely fall within this clade because it is located between two other populations that occur within this clade];

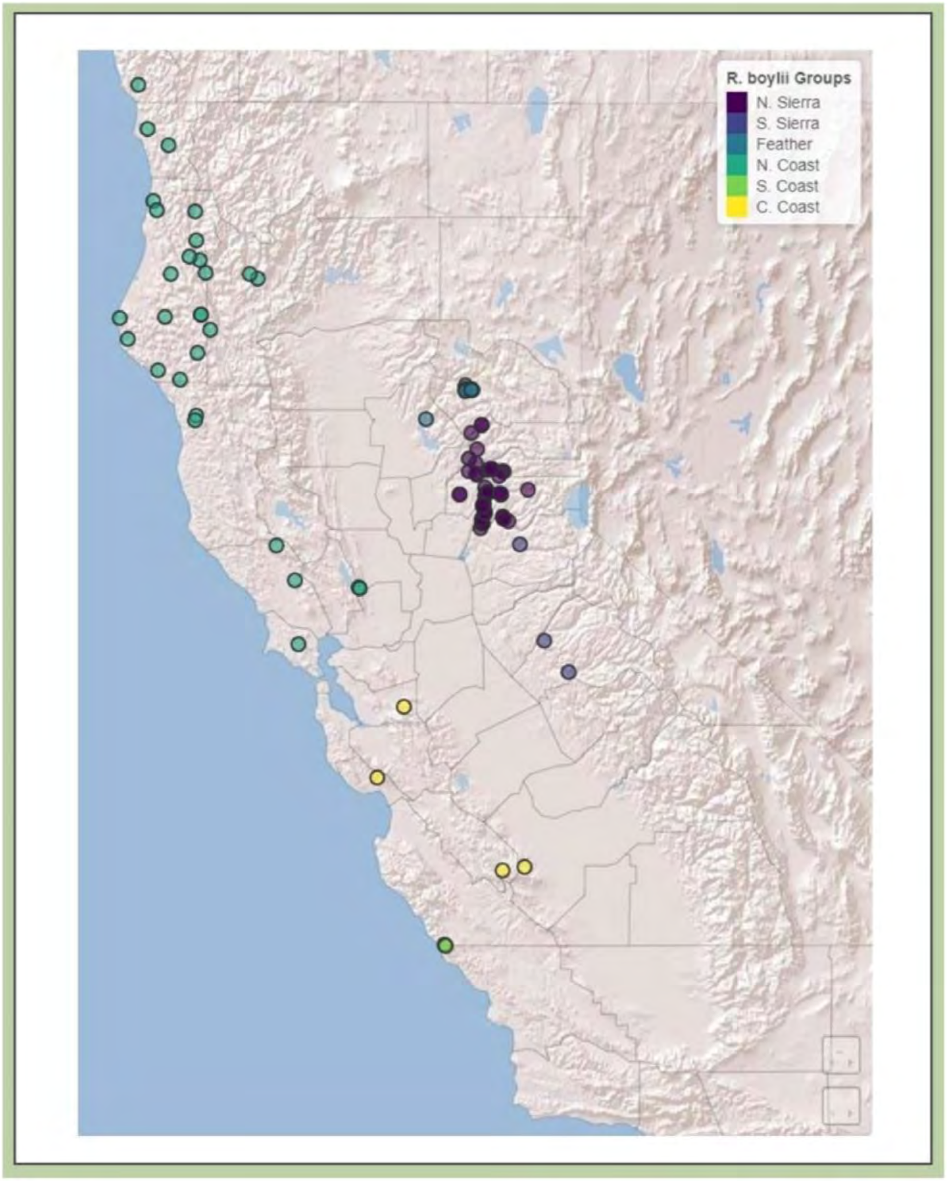

Figure 3. Foothill Yellow-legged Frog clades by Peek (2018)

(4) West/Central Coast: south of San Francisco Bay in the Coast Ranges to San Benito and Monterey counties, presumably east of the San Andreas Fault/Salinas Valley;

(5) Southwest/South Coast presumably west of the San Andreas Fault/Salinas Valley in Monterey County and south in the Coast Ranges.

The Feather River clade is found primarily in Plumas and Butte counties (Peek 2018). Peek's analysis found that this clade is as distinct as the rest of the Sierra Nevada as a cohesive group and all the coastal populations as one group, meaning it was found to be deeply divergent from the rest of the clades. McCartney-Melstad et al. (2018) also recognized the Feather River watershed as distinct from the rest of the northern Sierra but not as deeply divergent from the other clades as Peek. The Feather River watershed is also the only known location where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs (*R. sierrae*) co-occur and where two F1 hybrids (50% ancestry from each species) were found (Peek 2018). In addition, Peek's modeling results only weakly supported dividing the West/Central Coast and Southwest/South Coast groups into separate clades.

Previous work conducted by Lind et al. (2011) found a somewhat similar pattern, that populations on the periphery of the species' range are considerably genetically divergent from the rest of the range. Their results suggested that hydrologic regions and river basins were important landscape features that influenced the genetic structure of Foothill Yellow-legged Frog populations. However, using more modern genomic techniques, McCartney-Melstad et al. (2018) found nearly twice the variation among the five phylogenetic clades than among drainage basins, indicating other factors contributed to current population structure. They report that the depth of genetic divergence among Foothill Yellow-legged Frog clades exceeds that of any anuran (frog or toad) for which similar data are available and recommend using them as management units instead of the previously suggested watershed boundaries.

Levels of genetic diversity within the clades differed significantly. Genetic diversity gives species the ability to adapt to changing conditions (i.e., evolve), and its loss often signals extreme population and range reductions as well as potential inbreeding depression that can reduce survival and reproductive success (Lande and Shannon 1996, Hoffmann and Sgrò 2011, McCartney-Melstad et al. 2018). Loss of genetic diversity in Foothill Yellow-legged Frogs largely follows a north-to-south pattern with the southern clades (Southwest/South Coast and East/Southern Sierra) possessing the least amount (McCartney-Melstad et al. 2018, Peek 2018). In addition, these study results demonstrate that Foothill Yellow-legged Frogs have lost genetic diversity over time across their entire range except for the large Northwest/North Coast clade, which appears to have undergone a relatively recent population expansion (McCartney-Melstad et al. 2018, Peek 2018).

At a watershed scale, Dever (2007) found that tributaries to rivers and streams are important for preserving genetic diversity, and populations separated by more than 10 km (6.2 mi) show signs of genetic isolation. In other words, even in the absence of anthropogenic barriers to dispersal (e.g., dams and reservoirs), individuals located more than 10 km (6.2 mi) are not typically considered part of a single interbreeding population (Olson and Davis 2009). Peek (2011, 2018) reported that at this finer-scale, population structure and genetic diversity appear to be more strongly influenced by river regulation type (i.e., dammed or undammed) than to geographic distance or watershed boundaries. In general, regulated (dammed) rivers had limited gene flow and higher genetic divergence among subpopulations compared with unregulated (undammed) rivers (Peek 2011, 2018). In addition, differences in water flow regimes within regulated rivers affected connectivity (Peek 2011, 2018). Subpopulations in hydropeaking reaches, in which pulsed flows are used for electricity generation or whitewater boating, exhibited significantly lower gene flow than those in bypass reaches where water is diverted from upstream in the basin down to power generating facilities (Figure 4; Peek 2018). River regulation had a greater influence on genetic differentiation among sites than geographic distance in the Alameda Creek watershed as well (Stillwater Sciences 2012). Reduced connectivity among sites leads to lower gene flow and a loss of genetic diversity through genetic drift, which can diminish adaptability to changing environmental conditions (Palstra and Ruzzante 2008). Peek (2011) posits that given the *R. boylii* species group is estimated to be 8 million years old (Macey et al. 2001), the significant reductions in connectivity and genetic diversity over short evolutionary time periods in regulated rivers (often less than 50 years from the time of dam construction) is cause for concern with respect to population viability and persistence, particularly when combined with small population sizes.

Habitat Associations and Use

> *"These frogs are so closely restricted to streams that it is unusual to find one at a greater distance from the water than it could cover in one or two leaps."* – Richard G. Zweifel, 1955

Foothill Yellow-legged Frogs inhabit rivers and streams ranging from primarily rain-fed (coastal populations) to primarily snow-influenced (most Sierra Nevada and Klamath-Cascade populations) from headwater streams to large rivers (Bury and Sisk 1997, Wheeler et al. 2014). Occupied rivers and streams flow through a variety of vegetation types including hardwood, conifer, and valley-foothill riparian forests; mixed chaparral; and wet meadows (Hayes et al. 2016). Because the species is so widespread and can be found in so many types of habitats, the vegetation community is likely less important in determining Foothill Yellow-legged Frog occupancy and abundance than the aquatic biotic and abiotic conditions in the specific river, stream, or reach (Zweifel 1955). The species is an obligate stream-breeder, which sets it apart from other western North American ranids (Wheeler et al. 2014). Foothill Yellow-legged Frog habitat is generally characterized as partly-shaded, shallow, perennial rivers and streams with a low gradient and rocky substrate that is at least cobble-sized (Zweifel 1955, Hayes and Jennings 1988). However, the use of intermittent and ephemeral streams by post-metamorphic Foothill Yellow-legged Frogs may not be all that uncommon in some parts of the species' range in California (R. Bourque pers. comm. 2019). The species has been reported from some atypical habitats as well, including ponds, isolated pools in intermittent streams, and meadows along the edge of streams that lack a rocky substrate (Fitch 1938, Zweifel 1955, J. Alvarez pers. comm. 2017, CDFW 2018a).

As stream-breeding poikilotherms (animals whose internal temperature varies with ambient temperature), appropriate flow velocity, temperature, and water availability are critically important to Foothill Yellow-legged Frogs (Kupferberg 1996a, Van Wagner 1996, Wheeler et al. 2006, Lind et al. 2016). Habitat quality is also influenced by hydrologic regime (regulated vs. unregulated), substrate, presence of non-native predators and competitors, water depth, and availability of high-quality food and basking sites (Lind et al. 1996, Yarnell 2005, Wheeler et al. 2006, Catenazzi and Kupferberg 2017). Habitat suitability and use vary by life stage, sex, geographic location, watershed size, and season and

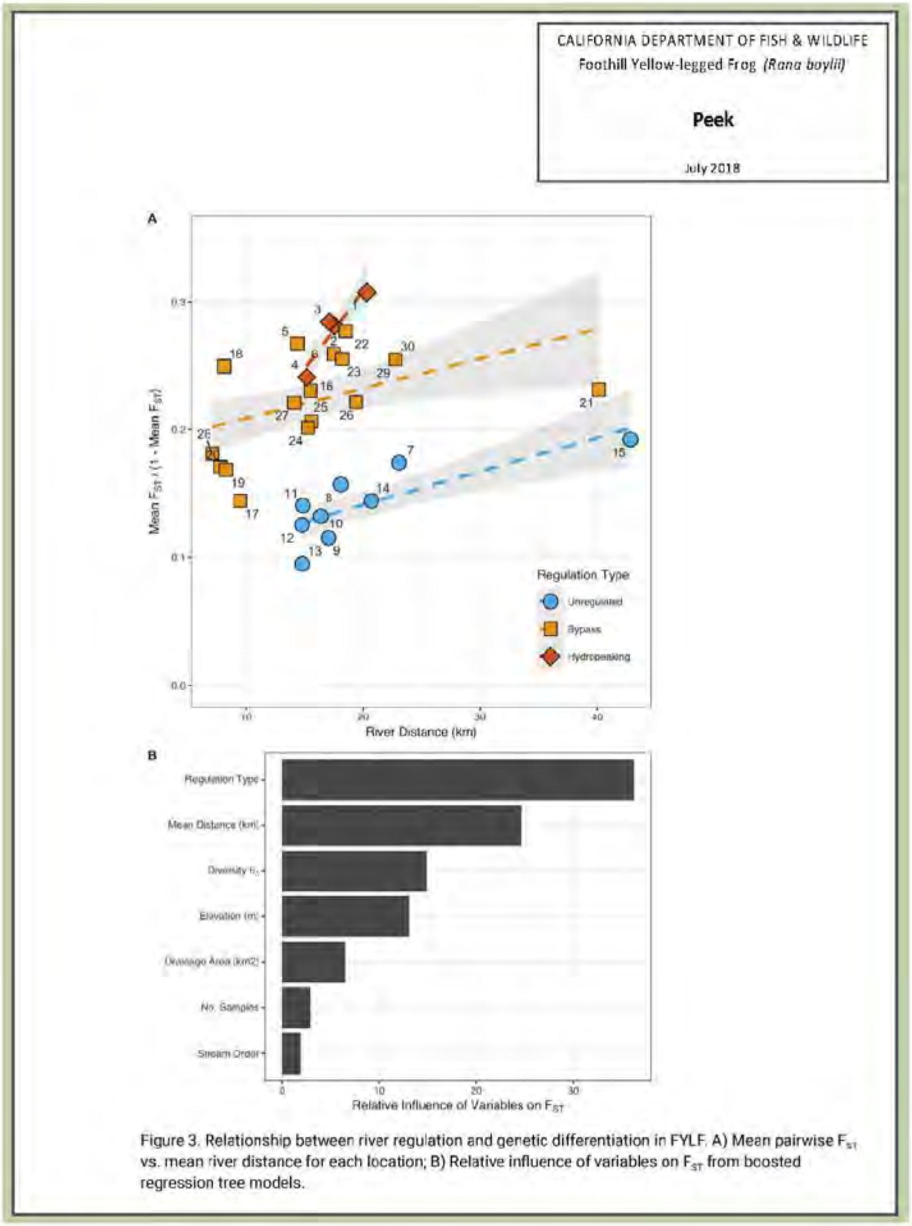

Figure 3. Relationship between river regulation and genetic differentiation in FYLF. A) Mean pairwise F_{ST} vs. mean river distance for each location; B) Relative influence of variables on F_{ST} from boosted regression tree models.

Figure 4. River regulation's relative influence on genetic differentiation from Peek (2018)

can generally be categorized as breeding and rearing habitat, nonbreeding active season habitat, and overwintering habitat (Van Wagner 1996, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011, Hayes et al. 2016, Catenazzi and Kupferberg 2017). Yarnell (2005) located higher densities of Foothill Yellow-legged Frogs in areas with greater habitat heterogeneity and suggested that they were selecting for sites that possessed the diversity of habitats necessary to support each life stage within a relatively short distance.

Breeding and Rearing Habitat

Suitable breeding habitat must be connected to suitable rearing habitat for metamorphosis to be successful. When this connectivity exists, as flows decline through the season, tadpoles can follow the receding shoreline into areas of high productivity and lower predation risk as opposed to becoming trapped in isolated pools with a high risk of overheating, desiccation, and predation (Kupferberg et al. 2009c).

Several studies on Foothill Yellow-legged Frog breeding habitat, carried out across the species' range in California, reported similar findings. Foothill Yellow-legged Frogs select oviposition (egg-laying) sites within a narrow range of depths, velocities, and substrates and exhibit fidelity to breeding sites that consistently possess suitable microhabitat characteristics over time (Kupferberg 1996a, Bondi et al. 2013, Lind et al. 2016). At a coarse-spatial scale, breeding sites in rivers and large streams are often located near the confluence of tributary streams in sunny, wide, shallow reaches (Kupferberg 1996a, Yarnell 2005, GANDA 2008, Peek 2011). These areas are highly productive compared to cooler, deeper, closed-canopy sites (Catenazzi and Kupferberg 2013). At a fine-spatial scale, females prefer to lay eggs in low velocity areas dominated by cobble- and boulder-sized substrates, often associated with sparsely-vegetated point bars (Kupferberg 1996a, Lind et al. 1996, Van Wagner 1996, Bondi et al. 2013, Lind et al. 2016). They tend to select areas with less variable, more stable flows, and in areas with higher flows at the time of oviposition, they place their eggs on the downstream side of large cobblestones and boulders, which protects them from being washed away (Kupferberg 1996a, Wheeler et al. 2006).

Appropriate rearing temperatures are vital for successful metamorphosis. Tadpoles grow faster and larger in warmer water to a point (Zweifel 1955; Catenazzi and Kupferberg 2017, 2018). Zweifel (1955) conducted experiments on embryonic thermal tolerance and determined that the critical low was approximate 6°C (43°F), and the critical high was around 26°C (79°F). Welsh and Hodgson (2011) determined that best the single variable for predicting Foothill Yellow-legged Frog presence was temperature since none were observed below 13°C (55°F), but numbers increased significantly with increasing temperature. Catenazzi and Kupferberg (2013) measured tadpole thermal preference at 16.5-22.2°C (61.7-72.0°F), and the distribution of Foothill Yellow-legged Frog populations across a watershed was consistent within this temperature range. ~~At~~ When the daily average temperatures during the warmest month of the year were below 16°C (61°F), tadpoles were absent under closed canopy and scarce even with an open canopy (Ibid.). Catenazzi and Kupferberg (2017) found regional differences in apparently suitable breeding temperatures. Inland populations from primarily snowmelt-fed systems with relatively cold water were relegated to reaches that are warmer on average during the warmest 30 days of the year than coastal populations in the chiefly rainfall-fed, and thus warmer, systems (17.6-

24.2°C [63.7-75.6°F] vs. 15.7-22.0°C [60.3-71.6°F], respectively). However, experiments on tadpole thermal preference demonstrated that individuals from different source populations selected similar rearing temperatures, which presumably optimized development (Ibid.). In regulated systems, where water released from dams is often colder than normal, suitable rearing temperatures downstream may be limited (Wheeler et al. 2014, Catenazzi and Kupferberg 2017).

Appropriate flow velocities are also critical for survival to metamorphosis. The velocity at which Foothill Yellow-legged Frog egg masses shear away from the substrate they are adhered to varies according to factors such as depth and degree to which the eggs are sheltered (Spring Rivers Ecological Sciences 2003). This critical velocity is expected to decrease as the egg mass ages due to their reduced structural integrity of the protective jelly envelopes (Hayes et al. 2016). Short-duration increases in flow velocity may be tolerated if the egg masses are somewhat sheltered, but sustained high velocities increase the likelihood of detachment (Kupferberg 1996a, Spring Rivers Ecological Sciences 2003). Hatchlings and tadpoles about to undergo metamorphosis are relatively poor swimmers and require especially slow, stable flows during these stages of development (Kupferberg et al. 2011b). Tadpoles respond to increasing flows by swimming against the current to maintain position for a short period of time and eventually swimming to the bottom and seeking refuge in the rocky substrate's interstitial spaces (Ibid.). When tadpoles are exposed to repeated increases in velocities, their growth and development are delayed (Ibid.). Under experimental conditions, the critical velocity at which tadpoles were swept downstream ranged between 20 and 40 cm/s (0.66-1.31 ft/s); however, as they reach metamorphosis it decreases to as low as 10 cm/s (0.33 ft/s) (Ibid.).

Nonbreeding Active Season Habitat

Post-metamorphic Foothill Yellow-legged Frogs utilize a more diverse range of habitats and are much more dispersed during the nonbreeding active season than the breeding season. Microhabitat preferences appear to vary by location and season, but some patterns are common across the species' range. Foothill Yellow-legged Frogs tend to remain close to the water's edge (average < 3 m [10 ft]); select sunny areas with limited canopy cover; and are often associated with riffles and pools (Zweifel 1955, Hayes and Jennings 1988, Van Wagner 1996, Welsh et al. 2005, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011). Adequate water, food resources, cover from predators, ability to thermoregulate (e.g., presence of basking sites and cool refugia), and absence of non-native predators are important components of nonbreeding active season habitat (Hayes and Jennings 1988, Van Wagner 1996, Catenazzi and Kupferberg 2013).

Overwintering Habitat

Overwintering habitat varies depending on local conditions, but as with the rest of the year, Foothill Yellow-legged Frogs are most often found in or near water where they can forage and take cover from predators and high discharge events (Storer 1925, Zweifel 1955). In larger streams and rivers, Foothill Yellow-legged Frogs are often found along tributaries during the winter where the risk of being displaced by heavy flows is reduced (Kupferberg 1996a, Gonsolin 2010). Bourque (2008) found 36.4% of adult females used intermittent and ephemeral tributaries during the overwintering season. Van

Wagner (1996) located most overwintering frogs using pools with cover such as boulders, root wads, and woody debris. During high flow events, they moved to the stream's edge and took cover under vegetation like sedges (*Carex* sp.) or leaf litter (Ibid.). Rombough (2006) found most Foothill Yellow-legged Frogs under woody debris along the high-water line and often using seeps along the stream-edge, which provided them with moisture, a thermally stable environment, and prey.

Exceptions to the pattern of remaining near the stream's edge during winter have been reported. Cook et al. (2012) observed dozens of juvenile Foothill Yellow-legged Frogs traveling over land, as opposed to using riparian corridors. They were found using upland habitats with an average distance of 71.3 m (234 ft) from water (range: 16-331 m [52-1,086 ft]) (Ibid.). In another example, a single subadult that was found adjacent to a large wetland complex 830 m (2,723 ft) straight-line distance from the wetted edge of the Van Duzen River, although it is possible the wetland was connected to the river via a spillway or drainage that may have served as the movement corridor (CDFW 2018a, R. Bourque pers. comm. 2019).

Seasonal Activity and Movements

Because Foothill Yellow-legged Frogs occupy areas with relatively mild winter temperatures, they can be active year-round, although at low temperatures (< 7°C [44 °F], they become lethargic (Storer 1925, Zweifel 1955, Van Wagner 1996, Bourque 2008). They are active both day and night, and during the day adults are often observed basking on warm objects such as sun-heated rocks, although this is also when their detectability is highest (Fellers 2005, Wheeler et al. 2005). By contrast, Gonsolin (2010) tracked radio-telemetered Foothill Yellow-legged Frogs under substrate a third of the time and underwater a quarter of the time, although nearly all his detections of frogs without transmitters were basking.

Adult Foothill Yellow-legged Frogs migrate from their overwintering sites to breeding habitat in the spring, often from a tributary to its confluence with a larger stream or river. In areas where tributaries dry down, juveniles also make this downstream movement (Haggarty 2006). When the tributary itself is perennial and provides suitable breeding habitat, the frogs may not undertake these long-distance movements (Gonsolin 2010). Cues for adults to initiate this migration to breeding sites are somewhat enigmatic and vary by location, elevation, and amount of precipitation (S. Kupferberg and A. Lind pers. comm. 2017). They can also include day length, water temperature, and sex (GANDA 2008, Gonsolin 2010, Yarnell et al. 2010, Wheeler et al. 2018). Males initiate movements to breeding sites where they congregate in leks (areas of aggregation for courtship displays), and females arrive later and over a longer period (Wheeler and Welsh 2008, Gonsolin 2010). Most males utilize breeding sites associated with their overwintering tributaries, but some move substantial distances to other sites and may use more than one breeding site in the same season (Wheeler and Welsh 2006, GANDA 2008).

While the predictable hydrograph in California consists of wet winters with high flows and dry summers with low flows, the timing and quantity of seasonal discharge can vary significantly from year to year. The timing of oviposition can influence offspring growth and survival. Early breeders risk scouring of egg masses from their substrate by late spring storms in wet years or desiccation if waters recede rapidly, but when they successfully hatch, tadpoles benefit from a longer growing season, which can enable them to metamorphose at a larger size and increase their likelihood of survival (Railsback et al. 2016).

Later breeders are less likely to have their eggs scoured away or desiccated because flows are generally more stable, but they have fewer mate choices, and their tadpoles have a shorter growing period before metamorphosis, reducing their chance of survival (Ibid.). Some evidence indicates larger females, who coincidentally lay larger clutches, breed earlier (Kupferberg et al. 2009c, Gonsolin 2010). Consequently, early season scouring or stranding of egg masses or tadpoles can disproportionately impact the population's reproductive output because later breeders produce fewer and smaller eggs per clutch (Kupferberg et al. 2009c, Gonsolin 2010).

Timing of oviposition is often a function of water temperature and flow, but it consistently occurs on the descending limb of the hydrograph which corresponds to high winter discharge gradually receding toward low summer baseflow (Kupferberg 1996a, GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010, Yarnell et al. 2010). Under natural conditions, the timing coincides with intermittent tributaries drying down and increases in algal blooms that provide forage for tadpoles (Haggarty 2006, Power et al. 2008). At lower elevations, breeding can start in late March or early April, and at mid-elevations, breeding typically occurs in mid-May to mid-June (Gonsolin 2010, S. Kupferberg and A. Lind pers. comm. 2017). The time of year a population initiates breeding can vary by a month among water years, occurring later at deeper sites when colder water becomes warmer (Wheeler et al. 2018). In wetter years, delayed breeding into early July can occur in some colder snowmelt systems (S. Kupferberg and A. Lind pers. comm. 2017, GANDA 2018).

A population's period of oviposition can also vary from two weeks to three months, meaning they could be considered explosive breeders at some sites and prolonged breeders at others (Storer 1925, Zweifel 1955, Van Wagner 1996, Ashton et al. 1997, Wheeler and Welsh 2008). Water temperature typically warms to over 10°C (50°F) before breeding commences (GANDA 2008, Gonsolin 2010, Wheeler et al. 2018). Wheeler and Welsh (2008) observed Foothill Yellow-legged Frogs breeding when flows were below 0.6 m/s (2 ft/s), pausing during increased flows until they receded, and GANDA (2008) reported breeding initiated when flow decreased to less than 55% above baseflow.

Male Foothill Yellow-legged Frogs spend more time at breeding sites during the season than females, many of whom leave immediately after laying their eggs (GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010). Daily movements are usually short (< 0.3 m [1 ft]), but some individuals travel substantial distances: median 70.7 m/d (232 ft/d) in spring and 37.1 m/d (104 ft/day) in fall/winter, nearly always using streams as movement corridors (Van Wagner 1996, Bourque 2008, Gonsolin 2010). The maximum reported movement rate is 1,386 m/d (0.86 mi/d), and the longest seasonal (post-breeding) daily distance reported is 7.04 km (4.37 mi) by a female that traveled up a dry tributary and over a ridge before returning to and moving up the mainstem creek (Bourque 2008). Movements during the non-breeding season are typically in response to drying channels or during rain events (Bourque 2008, Gonsolin 2010, Cook et al. 2012).

Hatchling Foothill Yellow-legged Frogs tend to remain with what is left of the egg mass for several days before dispersing into the interstitial spaces in the substrate (Ashton et al. 1997). They often move downstream in areas of moderate flow and will follow the location of warm water in the channel throughout the day (Brattstrom 1962, Ashton et al. 1997, Kupferberg et al. 2011a). Tadpoles usually

metamorphose in late August or early September (S. Kupferberg and A. Lind pers. comm. 2017). Twitty et al. (1967) reported that newly metamorphosed Foothill Yellow-legged Frogs mostly migrated upstream, which may be an evolutionary mechanism to return to their natal site after being washed downstream (Ashton et al. 1997).

Home Range and Territoriality

Foothill Yellow-legged Frogs exhibit a lek-type mating system in which males aggregate at the breeding site and establish calling territories (Wheeler and Welsh 2008, Bondi et al. 2013). The species has a relatively large calling repertoire for western North American ranids with seven unique vocalizations recorded (Silver 2017). Some of these can be reasonably attributed to territory defense and mate attraction communications (MacTeague and Northen 1993, Silver 2017). Physical aggression among males during the breeding season has been reported (Rombough and Hayes 2007, Wheeler and Welsh 2008). In addition, Wheeler and Welsh (2008) observed a non-random mating pattern in which males engaged in amplexus with females were larger than males never seen in amplexus, suggesting either physical competition or female preference for larger individuals. Very little information has been published on Foothill Yellow-legged Frog home range size. Wheeler and Welsh (2008) studied males during a 17-day period during breeding season and classified some of them "site faithful" based on their movements and calculated their home ranges. Two-thirds of males tracked were site faithful, and their mean home range size was 0.58 m^2 (SE = 0.10 m^2; 6.24 ft^2 [SE = 1.08 ft^2]) (Ibid.). In contrast, perhaps because the study took place over a longer time period, Bourque (2008) reported approximately half of the males he tracked during the spring were mobile, and the other half were sedentary. The median distances traveled along the creek (a proxy for home range size since they rarely leave the riparian corridor) for mobile and sedentary males were 149 m (489 ft) and 5.5 m (18 ft), respectively.

Diet and Predators

Foothill Yellow-legged Frog diet varies by life stage and likely body size. Tadpoles graze on periphyton (algae growing on submerged surfaces) scraped from rocks and vegetation and grow faster, and to a larger size, when it contains a greater proportion of epiphytic diatoms with nitrogen-fixing endosymbionts (*Epithemia* spp.), which are high in protein and fat (Kupferberg 1997b, Fellers 2005, Hayes et al. 2016, Caten~~n~~azzi and Kupferberg 2017). Tadpoles may also forage on necrotic tissue from dead bivalves and other tadpoles, or more likely the algae growing on them (Ashton et al. 1997, Hayes et al. 2016). Post-metamorphic Foothill Yellow-legged Frogs primarily feed on a wide variety of terrestrial arthropods but also some aquatic invertebrates (Fitch 1936, Van Wagner 1996, Haggarty 2006). Most of their diet consists of insects and arachnids (Van Wagner 1996, Haggarty 2006, Hothem et al. 2009). Haggarty (2006) did not identify any preferred taxonomic groups, but she noted larger Foothill Yellow-legged Frogs consumed a greater proportion of large prey items compared to smaller individuals, suggesting the species may be gape-limited generalist predators. Hothem et al. (2009) found mammal hair and bones in a Foothill Yellow-legged Frog. Adult Foothill Yellow-legged Frogs, like many other ranids, also cannibalize conspecifics (Wiseman and Bettaso 2007). In the fall when young-of-year are abundant, they may provide an important source of nutrition for adults prior to overwintering (Ibid.).

Foothill Yellow-legged Frogs are preyed upon by several native and introduced species, including each other as described above. Some predators target specific life stages, while others may consume multiple stages. Several species of gartersnakes (genus *Thamnophis*) are the primary and most widespread group of native predators on Foothill Yellow-legged Frogs tadpoles through adults is (Fitch 1941, Fox 1952, Zweifel 1955, Lind and Welsh 1994, Ashton et al. 1997, Wiseman and Bettaso 2007, Gonsolin 2010). Table 1 lists other known and suspected predators of Foothill Yellow-legged Frogs.

Table 1. Confirmed and potential Foothill Yellow-legged Frog predators in California in addition to gartersnakes (*Thamnophis* spp.)

Common Name	Scientific Name	Classification	Native	Prey Life Stage(s)	Sources
Caddisfly (larva)	*Dicosmoecus gilvipes*	Insect	Yes	Embryos (eggs)	Rombough and Hayes 2005
Dragonfly (nymph)	*Aeshna walker*	Insect	Yes	Larvae	Catenazzi and Kupferberg 2018
Waterscorpion	*Ranatra brevicollis*	Insect	Yes	Larvae	Catenaazi and Kupferberg 2018
Signal Crayfish	*Pacifastacus leniusculus*	Crustacean	No	Embryos (eggs) and Larvae	Rombough and Hayes 2005; Wiseman et al. 2005
Speckled Dace	*Rhinichthys osculus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Reticulate Sculpin	*Cottus perplexus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Sacramento Pike Minnow	*Ptychocheilus grandis*	Fish	Yes*	Embryos (eggs) and Adults	Ashton and Nakamoto 2007
Sunfishes	Family Centrachidae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Catfishes	Family Ictaluridae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Rough-skinned Newt	*Taricha granulosa*	Amphibian	Yes	Embryos (eggs)	Evenden 1948
California Giant Salamander	*Dicamptodon ensatus*	Amphibian	Yes	Larvae	Fidenci 2006
American Bullfrog	*Rana catesbeiana*	Amphibian	No	Larvae to Adults	Crayon 1998; Hothem et al. 2009
California Red-legged Frog	*Rana draytonii*	Amphibian	Yes	Larvae to Adults	Gonsolin 2010
American Robin	*Turdus migratorius*	Bird	Yes	Larvae	Gonsolin 2010
Common Merganser	*Mergus merganser*	Bird	Yes	Larvae	Gonsolin 2010
American Dipper	*Cinclus mexicanus*	Bird	Yes	Larvae	Ashton et al. 1997
Mallard	*Anas platyrhynchos*	Bird	Yes	Adults	Rombough et al. 2005
Raccoon	*Procyon lotor*	Mammal	Yes	Larvae to Adults	Zweifel 1955; Ashton et al. 1997
River Otter	*Lontra canadensis*	Mammal	Yes	Adults	T. Rose pers. comm. 2014

* Introduced to the Eel River, location of documented predation; Foothill Yellow-legged Frogs are extirpated from most areas of historical range overlap

STATUS AND TRENDS IN CALIFORNIA

Administrative Status

Sensitive Species

The Foothill Yellow-legged Frog is listed as a Sensitive Species by the U.S. Bureau of Land Management (BLM) and U.S. Forest Service (Forest Service). These agencies define Sensitive Species as those species that require special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA.

California Species of Special Concern

The Department's Species of Special Concern (SSC) designation is similar to the federal Sensitive Species designation. It is administrative, rather than regulatory in nature, and intended to focus attention on animals at conservation risk. The designation is used to stimulate needed research on poorly known species and to target the conservation and recovery of these animals before they meet the CESA criteria for listing as threatened or endangered (Thomson et al. 2016). The Foothill Yellow-legged Frog is listed as a Priority 1 (highest risk) SSC (Ibid.).

Trends in Distribution and Abundance

Range-wide in California

Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551). Systematic, focused, range-wide assessments of Foothill Yellow-legged Frog distribution and abundance are rare, both historically and contemporarily. A detailed account of what has been documented within the National Parks and National Forests in California can be found in Appendix 3 of the *Foothill Yellow-legged Frogs Conservation Assessment in California* (Hayes et al. 2016).

Most Foothill Yellow-legged Frog records are incidental observations made during stream surveys for ESA-listed salmonids and simply document presence at a particular date and location, although some include counts or estimates of abundance by life stage. This makes assessing trends in distribution and abundance difficult despite a relatively large number of observations compared to many other species tracked by the California Natural Diversity Database (CNDDB). The CNDDB contained 2,366 Foothill Yellow-legged Frog occurrences in its March 2019 edition, 500 of which are documented from the past 5 years.

A few wide-ranging survey efforts that included Foothill Yellow-legged Frogs exist. Reports from early naturalists suggest Foothill Yellow-legged Frogs were relatively common in the Coast Ranges as far south as central Monterey County, in eastern Tehama County, and in the foothills in and near Yosemite National Park (Grinnell and Storer 1924, Storer 1925, Grinnell et al. 1930, Martin 1940). In addition to

these areas, relatively large numbers of Foothill Yellow-legged Frogs (17-35 individuals) were collected at sites in the central and southern Sierra Nevada and the San Gabriel Mountains between 1911 and 1950 (Hayes et al. 2016). Widespread disappearances of Foothill Yellow-legged Frog populations were documented as early as the 1970s and 80s in southern California, the southern Coast Range, and the central and southern Sierra Nevada foothills (Moyle 1973, Sweet 1983).

Twenty-five years ago, the Department published the first edition of *Amphibians and Reptile Species of Special Concern in California* (Jennings and Hayes 1994). The authors revisited hundreds of localities that had historically been occupied by Foothill Yellow-legged Frogs between 1988 and 1991 and consulted local experts to determine presumed extant or extirpated status. Based on these survey results and stressors observed on the landscape, they considered Foothill Yellow-legged Frogs endangered in central and southern California south of the Salinas River in Monterey County. They considered the species threatened in the west slope drainages of the Cascade Mountains and Sierra Nevada east of the Central Valley, and they considered the remainder of the range to be of special concern (Ibid.).

Fellers (2005) and his field crews conducted surveys for Foothill Yellow-legged Frogs throughout California. They visited 804 sites across 40 counties with suitable habitat within the species' historical range. They detected at least one individual at 213 sites (26.5% of those surveyed) over 28 counties. They located Foothill Yellow-legged Frogs in approximately 40% of streams in the North Coast, 30% in the Cascade Mountains and south of San Francisco in the Coast Range, and 12% in the Sierra Nevada. Fellers estimated population abundance was 20 or more adults at only 14% of the sites where the species was found and noted the largest and most robust populations occurred along the North Coast. In addition, to determine status of Foothill Yellow-legged Frogs across the species' range and potential causes for declines, Lind (2005) used previously published status accounts, species expert and local biologist professional opinions, and field visits to historically occupied sites between 2000-2002. She determined that Foothill Yellow-legged Frogs had disappeared from 201 of 394 of the sites, representing just over 50%. The coarse-scale trend in California is one of greater population declines and extirpations in lower elevations and latitudes (Davidson et al. 2002).

Few site-specific population trend data are available from which to evaluate status. However, long-term monitoring efforts often use egg mass counts as a proxy to estimate adult breeding females. The results of these studies often reveal extreme interannual variability in number of egg masses laid (Ashton et al. 2010, S. Kupferberg and M. Power pers. comm. 2015, Peek and Kupferberg 2016). In a meta-analysis of egg mass count data collected across the species' range in California over the past 25 years, Peek and Kupferberg (2016) reported declines in two unregulated rivers and an increase in another. Their models did not detect any significant trends in abundance across different locations or regulation type (dammed or undammed); however, high interannual variability can render trend detection difficult. Interannual variability was substantially greater in regulated rivers vs. unregulated; the median coefficient of variation was 66.9% and 41.6%, respectively (Ibid.). The greater variability in regulated rivers decreases the probability of detecting significant declines, and coupled with low abundance, it can lead to populations dropping below a density necessary for persistence without detection, resulting in extirpation.

Regional differences in Foothill Yellow-legged Frog persistence across its range have been recognized for nearly 50 years (i.e., more extirpations documented in the south). Because of these differences and the recent availability of new landscape genomic data, more detailed descriptions of trends in Foothill Yellow-legged Frog population distribution and abundance in California are evaluated by clade below. Figure 5 depicts Foothill Yellow-legged Frog localities across all clades in California by the most recent confirmed sighting in the datasets available to the Department within a Public Lands Survey System (PLSS) section. "Transition Zones" are those areas where the exact clade boundaries are unknown due to a lack of samples. In addition, while not depicted as an area of uncertainty, no genetic samples have been tested south of the extant population in northern San Luis Obispo County, in the Sutter Buttes in Sutter County, or northeastern Plumas County. It is possible there were historically more clades than currently understood.

Caution should be exercised in comparing the following observation data across the species' range and across time since survey effort and reporting are not standardized. These data can be useful for making some general inferences about distribution, abundance, and trends. For instance, assuming the observation correctly identifies the species, the date on the record is the last time the species was confirmed to have occurred at that location. However, this only works in the affirmative. For example, at a site where the last time the species was seen was 75 years ago, the species may still persist there if no one has surveyed it since the original observation. CNDDB staff use information on land use conversion, follow-up visits, and biological reports to categorize an occurrence location as "extirpated" or "possibly extirpated".

Northwest/North Coast Clade

This clade extends from north of San Francisco Bay through the Coast Range and Klamath Mountains to the northern limit of the Foothill Yellow-legged Frog's range and east through the Cascade Range. It includes Del Norte, Siskiyou, Humboldt, Trinity, Shasta, Tehama, Mendocino, Glenn, Colusa, Lake, Sonoma, Napa, Yolo, Solano, and Marin counties. This clade covers the largest geographic area and contains the greatest amount of genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). In addition, it is the only clade with an increasing trend in genetic diversity (Peek 2018).

Early records note the comparatively high abundance of Foothill Yellow-legged Frogs in this area. Storer (1925) described Foothill Yellow-legged Frogs as very common in many of Coast Range streams north of San Francisco Bay, and Cope (1879,1883 as cited in Hayes et al. 2016) noted they were "rather abundant in the mountainous regions of northern California." In addition, relatively large collections occurred over short periods of time in this region in the late 1800s and the first half of the 20th century (Hayes et al. 2016). Nineteen were taken over two weeks in 1893 along Orrs Creek, a tributary to the Russian River, and 40 from near Willits (both in Mendocino County) in 1911; 112 were collected over three days at Skaggs Spring (Sonoma County) in 1911; 57 were taken in one day along Lagunitas Creek (Marin County) in 1928; and 50 were collected in one day near Denny (Trinity County) in 1955 (Ibid.).

A few long-term Foothill Yellow-legged Frog egg mass monitoring efforts undertaken within this clade's boundaries found densities vary significantly, often based on river regulation type, and documented

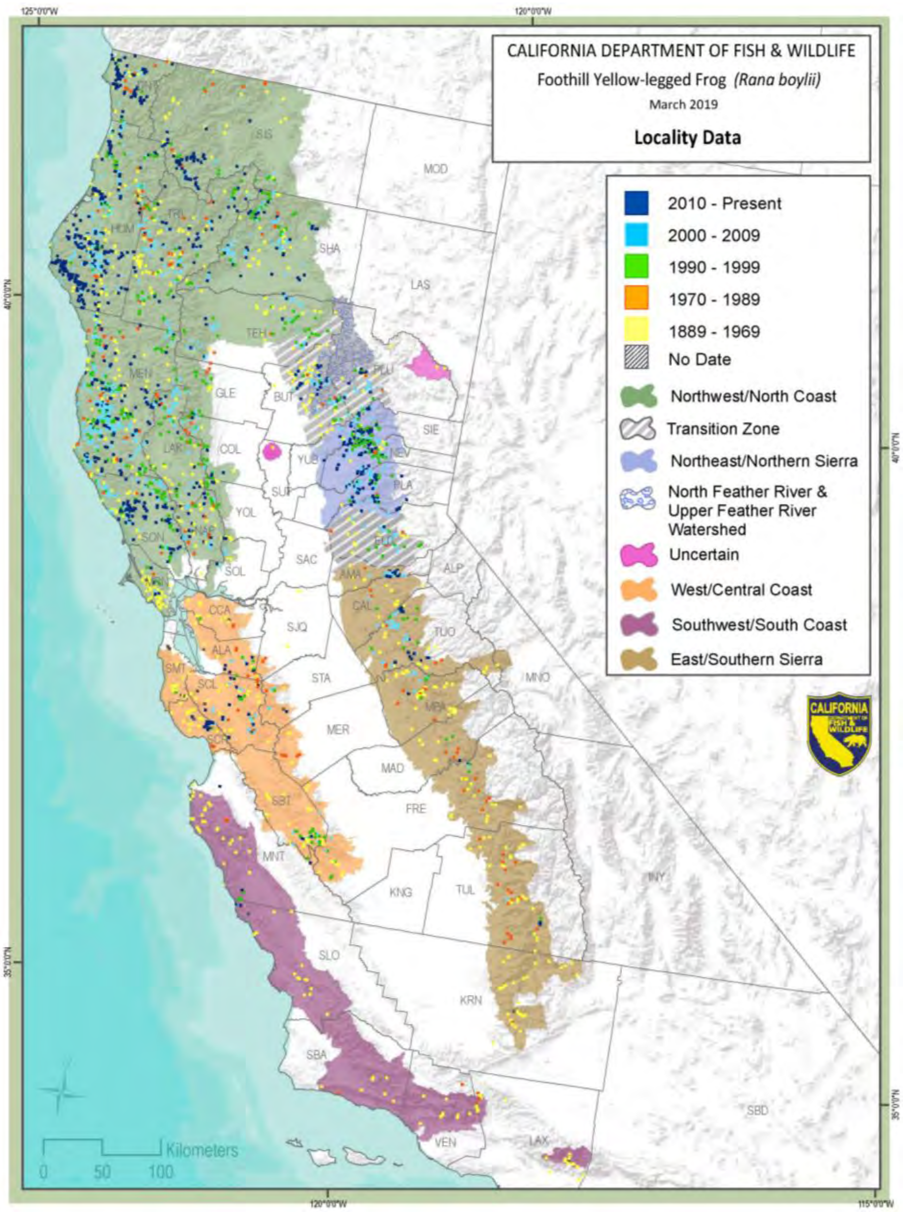

Figure 5. Foothill Yellow-legged Frog occurrence data from 1889-2019 overlaying the six clades by most recent sighting in a Public Lands Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

several robust populations. The Green Diamond Resources Company has been monitoring a stretch of the Mad River near Blue Lake (Humboldt County) since 2008 (GDRC 2018). The greatest published density of Foothill Yellow-legged Frog egg masses was documented here in 2009 at 323.6 egg masses/km (520.7/mi) (Bourque and Bettaso 2011). However, in 2017, surveyors counted 625.1 egg masses/km (1,006/mi) along the same reach (GDRC 2018). At its lowest during this period, egg mass density was calculated at 71.54/km (115.1/mi) in 2010, although this count occurred after a flooding even that likely scoured over half of the egg masses laid that season (GDRC 2018, R. Bourque pers. comm. 2019). During a single day survey in 2017 along approximately 2 km (1.3 mi) of Redwood Creek in Redwood National Park (Humboldt County), 2,009 young and 126 adult Foothill Yellow-legged Frogs were found (D. Anderson pers. comm. 2017). Some reaches of the South Fork Eel River (Mendocino County) also support high densities of Foothill Yellow-legged Frogs. Kupferberg (pers. comm. 2018) recorded 206.9 and 106.2 egg masses/km (333 and 171/mi) along two stretches in 2016, and 201.7 and 117.5 egg masses/km (324 and 189/mi) in 2017. However, other reaches yielded counts as low as 6.1 and 8.4 egg masses/km (9.8 and 13.5/mi) (Ibid.). In the Angelo Reserve (an unregulated reach), the 24-year mean density was 109 egg masses/km (175.4/mi) (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015). In contrast, a 10-year mean density of egg masses below Lewiston Dam on the Trinity River (Trinity County) was 0.89/km (1.43/mi) (Ibid.).

Figure 6 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, Biological Information Observation System datasets, and personal communications that are color coded by the most recent date of detection. Within this clade, Foothill Yellow-legged Frogs were observed in at least 343 areas in the past 5 years (CNDDB 2019). The species remains widespread within many watersheds, although most observations only verify presence, or fewer than ten individuals or egg masses are recorded (Ibid.). Documented extirpations are comparatively rare, but also likely undetected or under-reported, and nearly all occurred just north of the high-populated San Francisco Bay area (Figure 7; Ibid.).

West/Central Coast

This clade extends south from the San Francisco Bay through the Diablo Range and down the peninsula through the Santa Cruz and Gabilan Mountains in the Coast Range east of the Salinas Valley. It includes most of Contra Costa, Alameda, San Mateo, Santa Cruz, Santa Clara, and San Benito counties; western San Joaquin, Stanislaus, Merced, and Fresno counties; and a small portion of eastern Monterey County. Records of Foothill Yellow-legged Frogs occurring south of San Francisco Bay did not exist until specimens were collected in 1918 around what is now Pinnacles National Park in San Benito County, and little information exists on historical distribution and abundance within this clade (Storer 1923).

Within this clade, Foothill Yellow-legged Frogs were observed in at least 24 areas in the past five years (Figure 8; CNDDB 2019). Documented and possible extirpations are concentrated around the San Francisco Bay and sites at the southern portion of the clade's range, although these may not have been resurveyed since their original observations in the 1940s through 1960s, except for a site in Pinnacles National Park that was surveyed in 1994 (Figure 9; Ibid.). In addition, although not depicted,

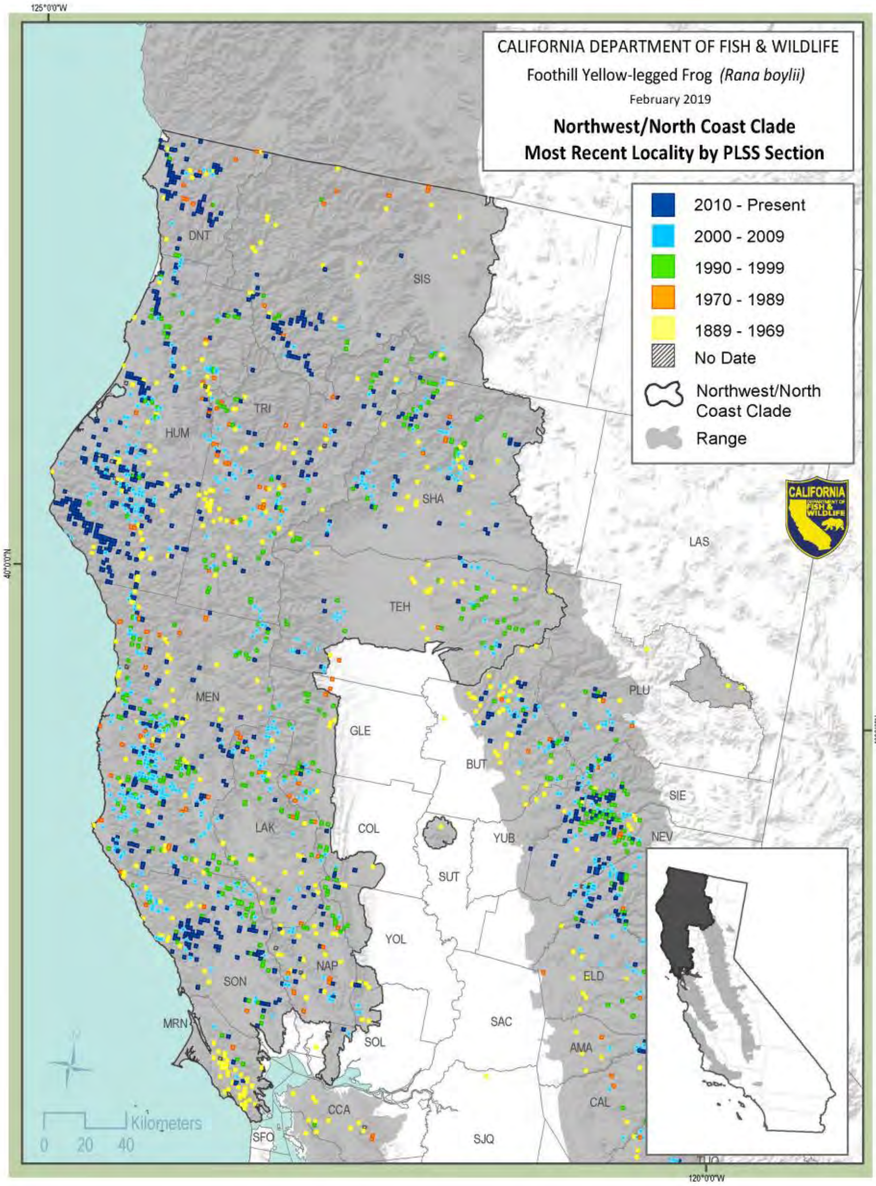

Figure 6. Close-up of Northwest/North Coast Foothill Yellow-legged Frog clade observations from 1889-2019 (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

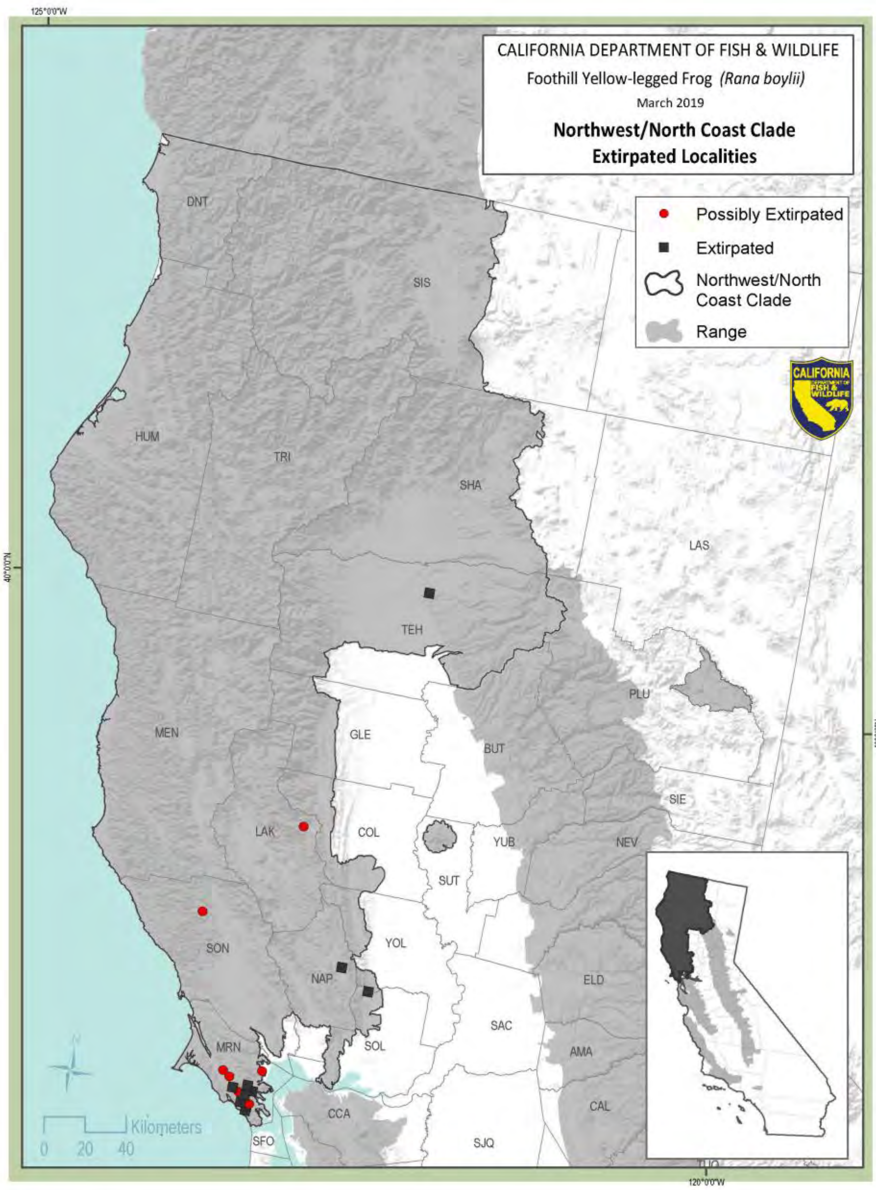

Figure 7. Possibly extirpated and extirpated Northwest/North Coast Foothill Yellow-legged Frog clade sites (CNDDB)

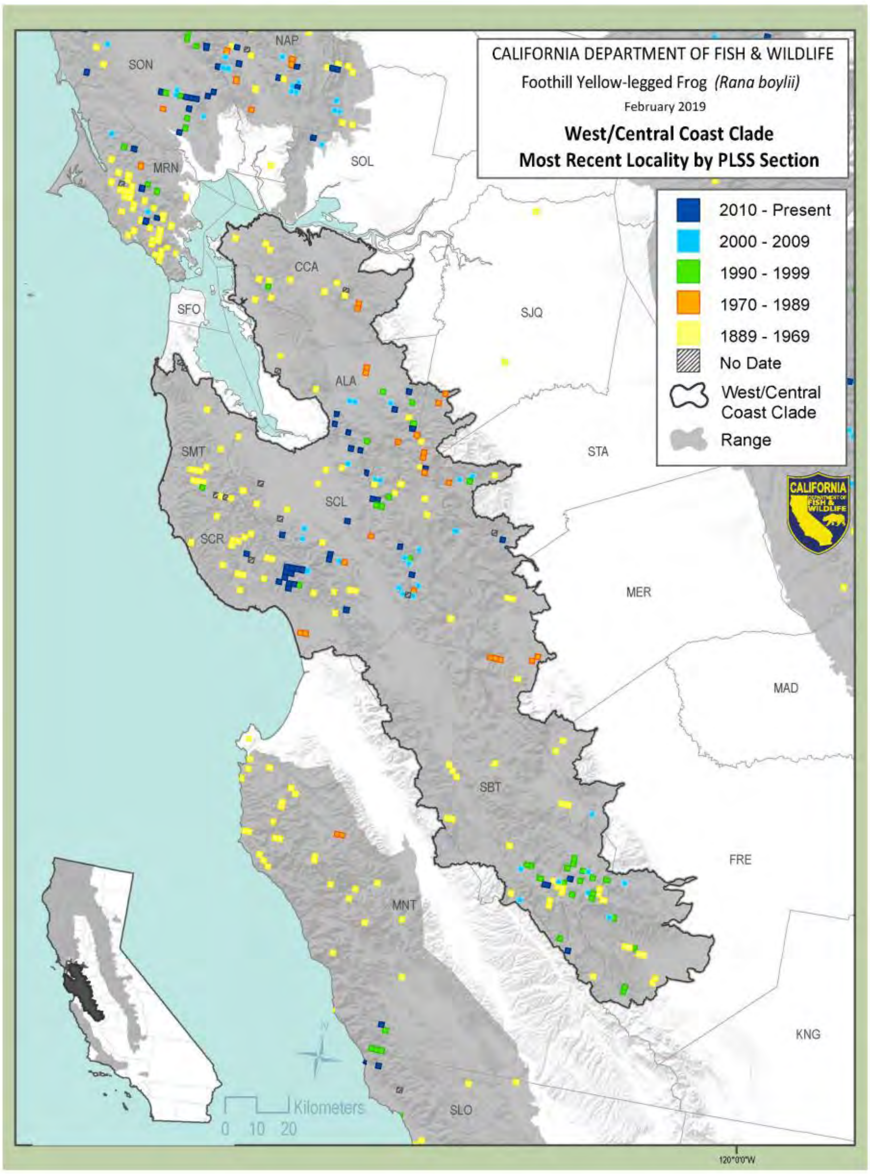

Figure 8. Close-up of West/Central Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

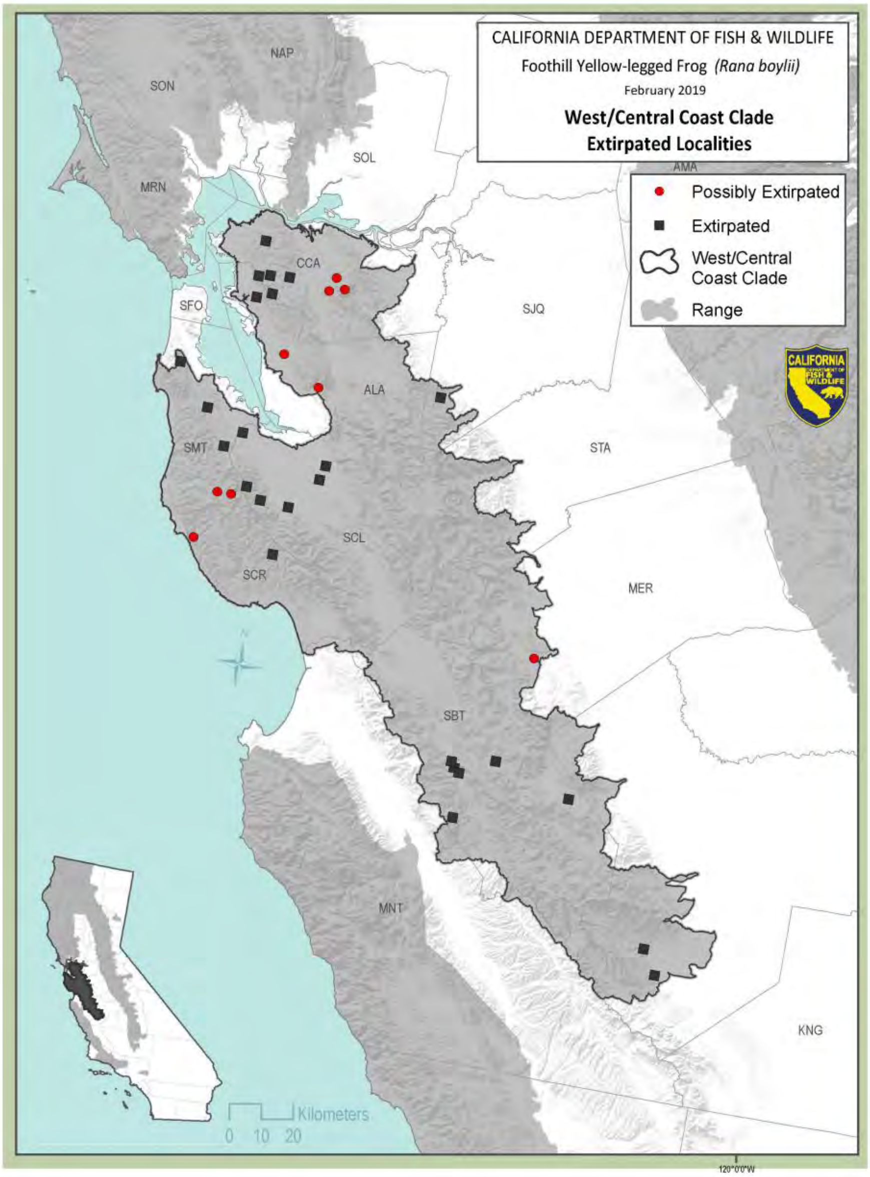

Figure 9. Possibly extirpated and extirpated West/Central Coast Foothill Yellow-legged Frog clade sites (CNDDB)

two populations on Arroyo Mocho and Arroyo Valle south of Livermore (Alameda County) are also likely extirpated (M. Grefsrud pers. comm. 2019).

The San Francisco Bay Area is heavily urbanized. Foothill Yellow-legged Frogs may be gone from Contra Costa County; eight of the nine CNDDB records from the county are museum specimens collected between 1891 and 1953, and the most recent observation was two adults in a plunge pool in an intermittent tributary to Moraga Creek in 1997. No recent (2010 or later) observations exist from San Mateo County (Ibid.). Historically occupied lower-elevation sites surrounding the San Francisco Bay and inland appear to be extirpated, but there are (or were) some moderately abundant breeding populations remaining at higher elevations in Arroyo Hondo (Alameda County), Alameda Creek (Alameda and Santa Clara counties), Coyote and Upper Llagas creeks (Santa Clara County), and Soquel Creek (Santa Cruz County) with some scattered smaller populations also persisting in these counties (J. Smith pers. comm. 2016, 2017; CNDDB 2019). The Alameda Creek and Coyote Creek populations recently underwent large-scale mortality events, so their numbers are likely substantially lower than what is currently reported in the CNDDB (Adams et al. 2017a, Kupferberg and Catenazzi 2019). In addition, the Arroyo Hondo population will lose approximately 1.6 km (1 mi) of prime breeding habitat (i.e., supported the highest density of egg masses on the creek) as the Calaveras Reservoir is refilled following its dam replacement project in 2019 (M. Grefsrud pers. comm. 2019). Foothill Yellow-legged Frogs may be extirpated from Corral Hollow Creek in San Joaquin County, but a single individual was observed five years ago further up the drainage in Alameda County within an Off-Highway Vehicle park (CNDDB 2019). Few recent sightings of Foothill Yellow-legged Frogs in the east-flowing creeks are documented. They may still be extant in the headwaters of Del Puerto Creek (western Stanislaus County), but the records further downstream indicate bullfrogs (known predators and disease reservoirs) are moving up the system (Ibid.). Several locations in southern San Benito, western Fresno, and eastern Monterey counties have relatively recent (2000 and later) detections (Ibid.). However, while many of these sites supported somewhat large populations in the 1990s, the more recent records report fewer than ten individuals (Ibid.). The exception is a Monterey County site where around 25 to 30 were observed in 2012 (Ibid.).

Southwest/South Coast

Widespread extirpations occurred decades ago, primarily in the 1960s and 1970s, in this area (Adams et al. 2017b). As a result, genetic samples were largely unavailable, and the boundaries are speculative. The clade is presumed to include the Coast Range from Monterey Bay south to the Transverse Range across to the San Gabriel Mountains. This clade includes portions of Monterey, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties. Storer (1923) reported that Foothill Yellow-legged Frogs were collected for the first time in Monterey County in 1919 and that a specimen collected by Cope in 1889 in Santa Barbara and listed as *Rana temporaria pretiosa* may refer to the Foothill Yellow-legged Frog because as previously mentioned, the taxonomy of this species changed several times over the first century after it was named.

Foothill Yellow-legged Frogs had been widespread and fairly abundant in this area until the late 1960s (Figure 10) but were rapidly extirpated throughout the southern Coast Ranges and western Transverse

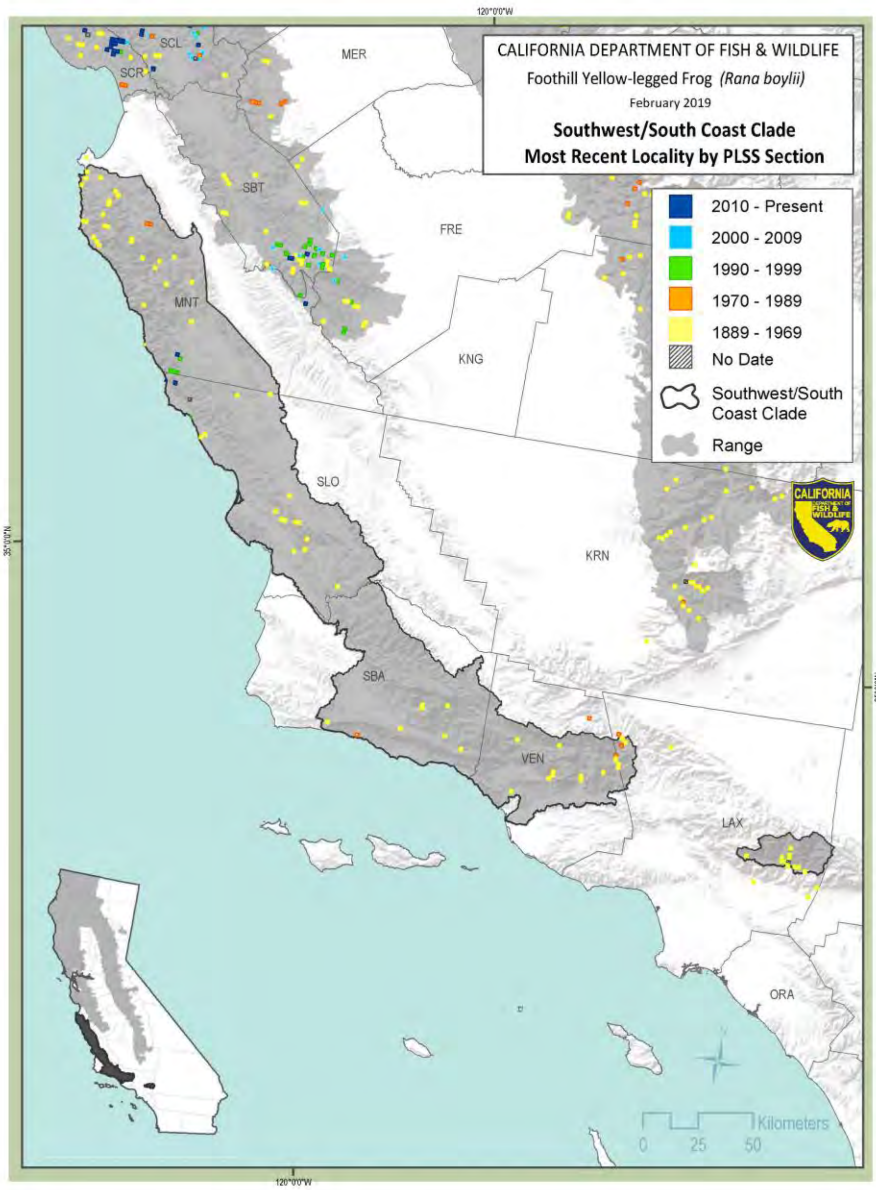

Figure 10. Close-up of Southwest/South Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

Ranges by the mid-1970s (Figure 11; Sweet 1983, Adams et al. 2017b). Only two known extant populations exist from this clade, located near the border of Monterey and San Luis Obispo counties (S. Sweet pers. comm. 2017, McCartney-Melstad et al. 2018, Peek 2018, CNDDB 2019). They appear to be extremely small and rapidly losing genetic diversity, making them at high risk of extirpation (McCartney-Melstad et al. 2018, Peek 2018).

Northeast/Feather River and Northern Sierra

The exact clade boundaries in the Sierra Nevada are unclear and will require additional sampling and testing to define (Figure 12). The Northeast clade presumably encompasses the Feather River and Northern Sierra clades. The Feather River clade is located primarily in Plumas and Butte counties. The Northern Sierra clade roughly extends from the Feather River watershed south to the Middle Fork American River. It includes portions of El Dorado, Placer, Nevada, Sierra, and Plumas counties. It may also include portions of Amador, Butte, and eastern Tehama counties. No genetic samples were available to test in the Sutter Buttes or the disjunct population in northeastern Plumas County to determine which clades they belonged to before they were extirpated (Figure 13; Olson et al. 2016, CNDDB 2019).

In general, there is a paucity of historical Foothill Yellow-legged Frog data for west-slope Sierra Nevada streams, particularly in the lower elevations of the Sacramento Valley, and no quantitative abundance data exist prior to major changes in the landscape (i.e., mining, dams, and diversions) or the introduction of non-native species (Hayes et al. 2016). Foothill Yellow-legged Frogs have been collected frequently from the Plumas National Forest area in small numbers from the turn of the 20th century through the 1970s (Ibid.). Estimates of relative abundance are not clear from the records, but they suggest the species was somewhat widespread in this area.

More recently, Foothill Yellow-legged Frog populations in the Sierra Nevada have been the subject of a substantial number of surveys and focused research associated with recent and ongoing relicensing of hydroelectric power generating dams by the Federal Energy Regulatory Commission (FERC). Consequently, Foothill Yellow-legged Frogs have been observed in at least 30 areas in Plumas and Butte counties (roughly the Feather River clade) over the past five years (CNDDB 2019). As with the rest of the range, most records are observations of only a few individuals; however, many observations occurred over multiple years, and in some cases all life stages were observed over multiple years (Ibid). The populations appear to persist even with the small numbers reported. The only long-term consistent survey effort has been occurring on the North Fork Feather River along the Cresta and Poe reaches (GANDA 2018). The Cresta reach's subpopulation declined significantly in 2006 and never recovered despite modification of the flow regime to reduce egg mass and tadpole scouring and some habitat restoration (Ibid.). A pilot project to augment the Cresta reach's subpopulation through in situ captive rearing was initiated in 2017 (Dillingham et al. 2018). It resulted in the highest number of young-of-year Foothill Yellow-legged Frogs recorded during fall surveys since researchers started keeping count (Ibid.). The number of egg masses laid in the Poe reach varies substantially year-to-year from a low of 26 in 2001 to a high of 154 in 2015 and back down to 36 in 2017 (GANDA 2018).

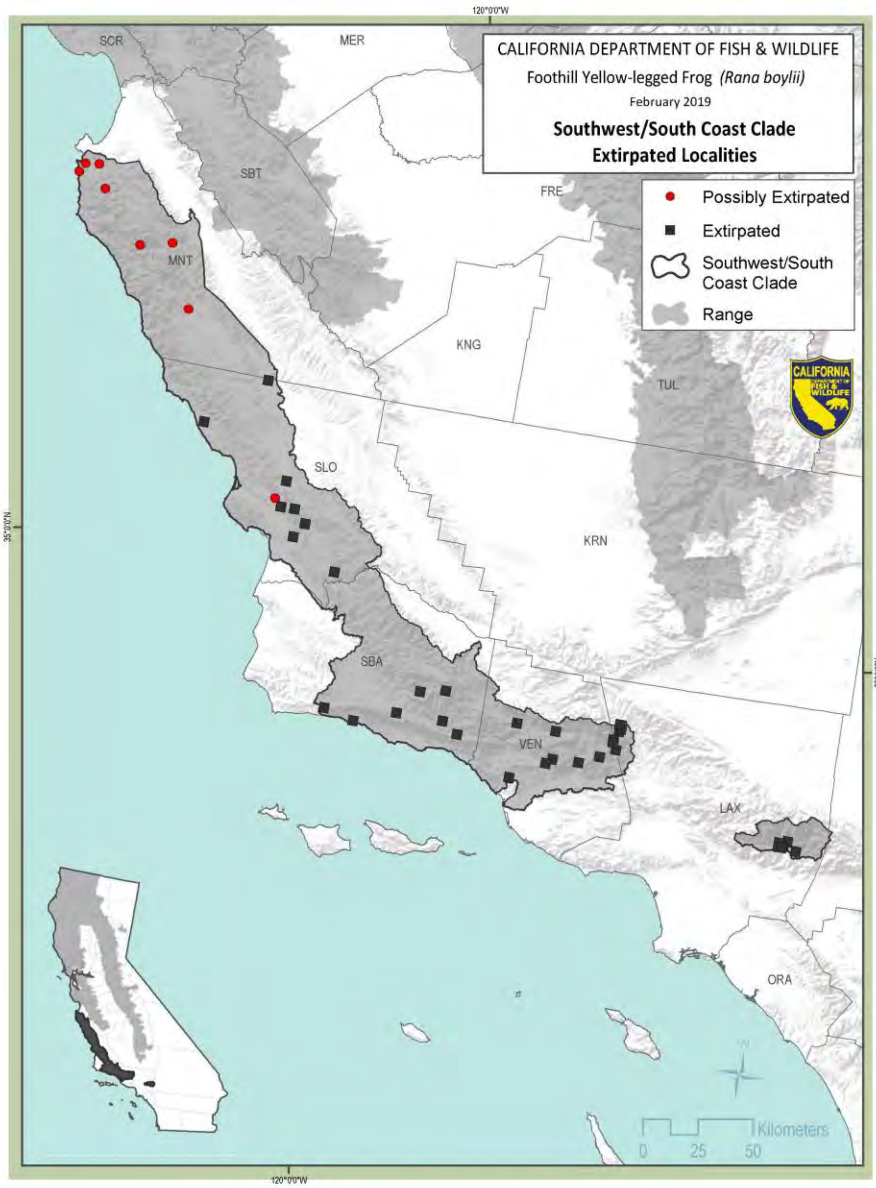

Figure 11. Possibly extirpated and extirpated Southwest/South Coast Foothill Yellow-legged Frog clade sites (CNDDB)

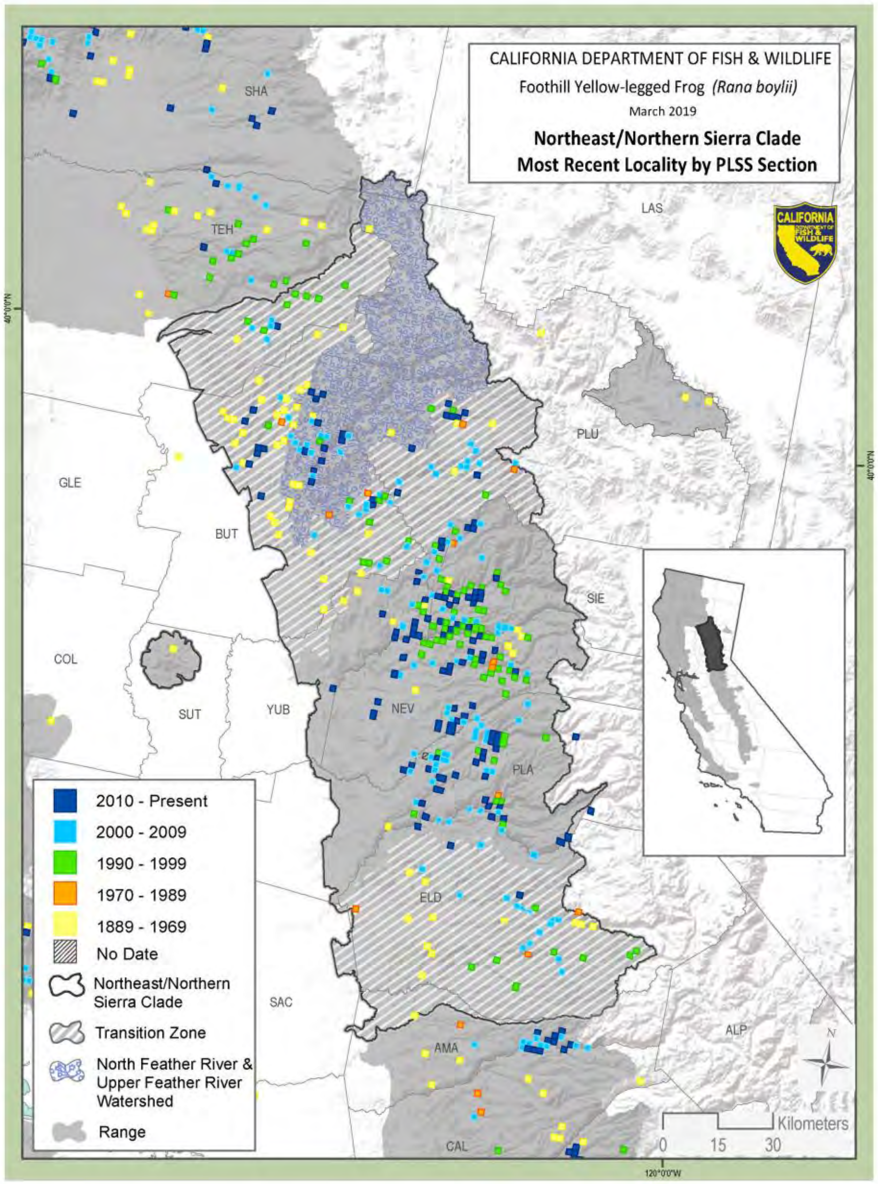

Figure 12. Close-up of Northeast/Feather River and Northern Sierra clades observations from 1889-2019 (ARSSC, BIOS, CNDDB)

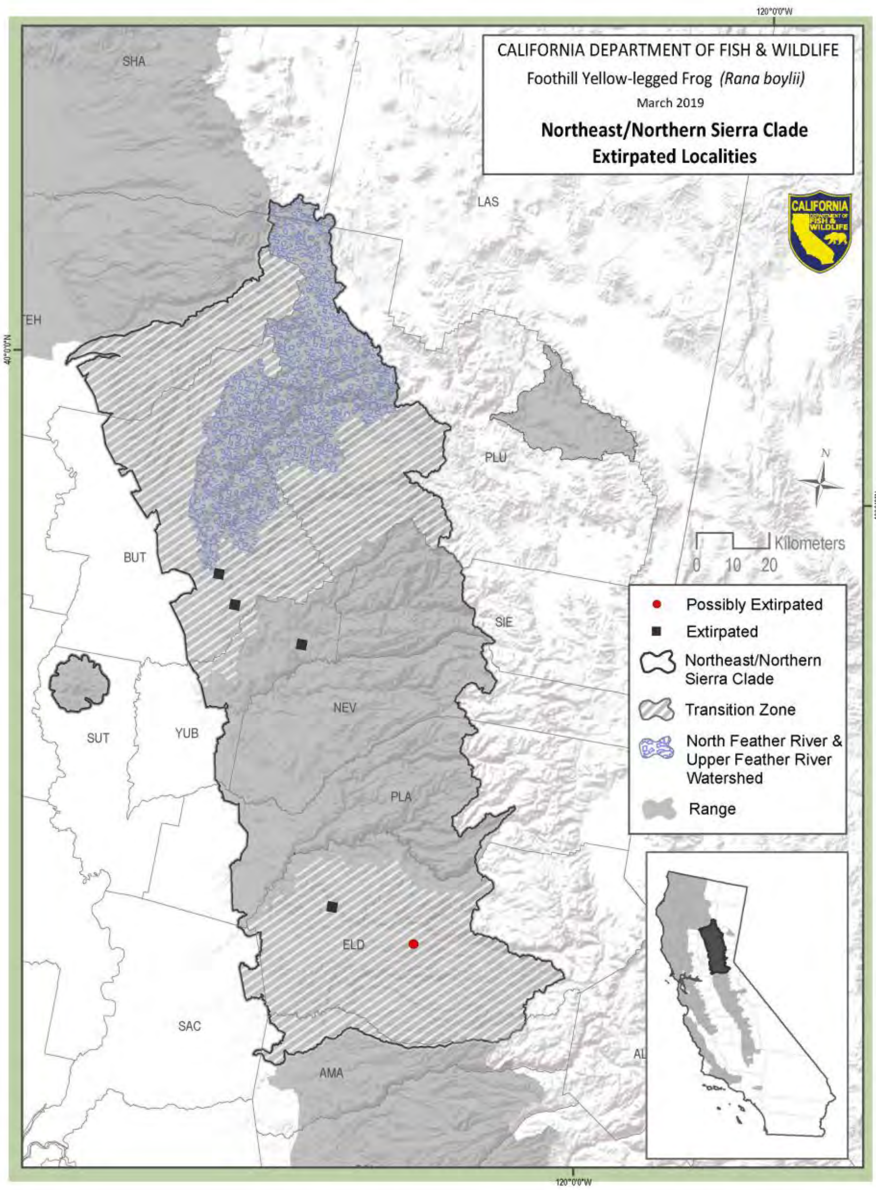

Figure 13. Possibly extirpated and extirpated Northeast/Feather River and Northern Sierra Foothill Yellow-legged Frog clades sites (CNDDB)

Foothill Yellow-legged Frogs have been observed in at least 71 areas in the past 5 years in the presumptive Northeast/Northern Sierra clade. The general pattern in this clade, and across the range for that matter, is that unregulated rivers or reaches have more areas that are occupied more consistently and in larger numbers than regulated rivers or reaches (CNDDB 2019, S. Kupferberg pers. comm. 2019). Foothill Yellow-legged Frogs were rarely observed in the hydropeaking reach of the Middle Fork American River and were observed in low numbers in the bypass reach, but they were present and breeding in small tributary populations (PCWA 2008). Relatively robust populations appear to inhabit the North Fork American River and Lower Rubicon River (Gaos and Bogan 2001, PCWA 2008, Hogan and Zuber 2012, K. Kundargi pers. comm. 2014, S. Kupferberg pers. comm. 2019). Additional apparently sufficiently large and relatively stable populations occur on Clear Creek, South Fork Greenhorn Creek, and Shady Creek (Nevada County) and the North and Middle Yuba River (Sierra County), but the remaining observations are of small numbers in tributaries with minimal connectivity among them (CNDDB 2019, S. Kupferberg pers. comm. 2019).

East/Southern Sierra

The East/Southern Sierra clade is presumed to range from the South Fork American River watershed, the northernmost site where individuals from this clade were collected, south to where the Sierra Nevada meets the Tehachapi Mountains. It likely includes El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, Fresno, Tulare, and Kern counties (Figure 14; Peek 2018). The proportion of extirpated sites in this clade is second only to the Southwest/South Coast and follows the pattern of greater losses in the south (Figure 15). Like the southern coastal clade, the southern Sierra clade has low genetic variability and a trajectory of continued loss of diversity (Ibid.).

Historical collections of small numbers of Foothill Yellow-legged Frogs occurred in every major river system within this clade beginning as early as the turn of the 20th century, indicating widespread distribution but little information on abundance (Hayes et al. 2016). By the early 1970s, declines in Foothill Yellow-legged Frog populations from this area were already apparent; Moyle (1973) found them at 30 of 95 sites surveyed in 1970. Notably bullfrogs inhabited the other 65 sites formerly occupied by Foothill Yellow-legged Frogs, and they co-occurred at only 3 sites (Ibid.). In 1992, Drost and Fellers (1996) revisited the sites around Yosemite National Park (Tuolumne and Mariposa counties) that Grinnell and Storer (1924) surveyed in 1915 and 1919. Foothill Yellow-legged Frogs had disappeared from all seven historically occupied sites and were not found at any new sites surveyed surrounding the park (Ibid.). Resurveys of previously occupied sites on the Stanislaus (Tuolumne County), Sierra (Fresno County), and Sequoia (Tulare County) National Forests were also undertaken (Lind et al. 2003b). Foothill Yellow-legged Frogs were absent from the sites in Sierra and Sequoia National Forests, six at each forest; however, a new population was discovered in the Sierra and two in the Sequoia forests (Ibid.). These populations remain extant but are small and isolated (CNDDB 2019). Two of the six sites on the Stanislaus were still occupied, and 19 new populations were found with evidence of breeding at seven of them (Lind et al. 2003b). Twenty of the 24 populations extant at the time inhabited unregulated waterways (Ibid.). Most of the CNDDB (2019) records of Foothill Yellow-legged Frogs on the Stanislaus are at least a decade old and are represented by low numbers.

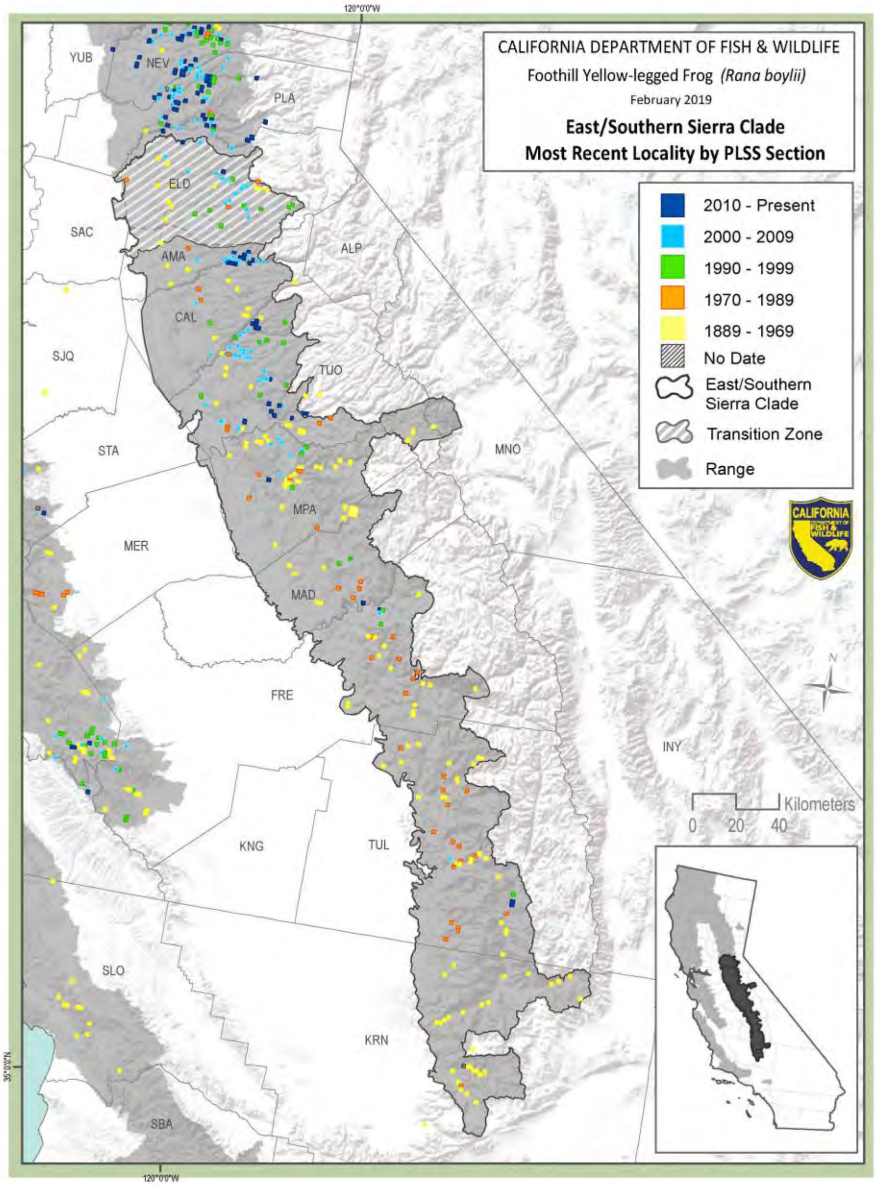

Figure 14. Close-up of East/Southern Sierra clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

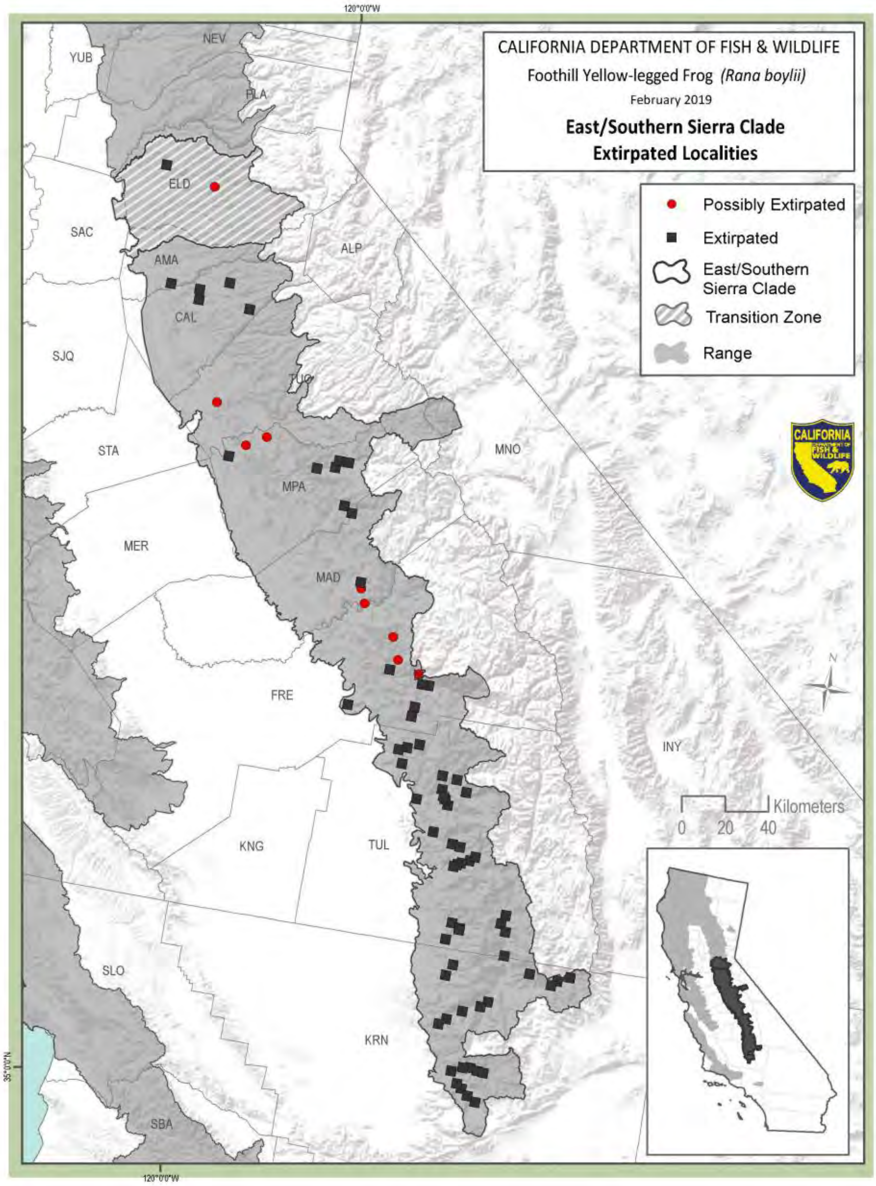

Figure 15. Possibly extirpated and extirpated East/Southern Sierra Foothill Yellow-legged Frog clade sites (CNDDB)

More recently, surveys for Foothill Yellow-legged Frogs were conducted along the South Fork American River as part of the El Dorado Hydroelectric Project's FERC license amphibian monitoring requirements (GANDA 2017). Between 2002 and 2016 counts of different life stages varied significantly by year but the trend for every life stage was a decline over that period (Ibid.). There appears to be a small population persisting along the North Fork Mokelumne River (Amador and Calaveras counties), but it was only productive during the 2012-2014 drought years (Ibid.). Small numbers have also been observed recently in several locations on private timberlands in Tuolumne County (CNDDB 2019).

FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

"The fortunes of the boylii *population fluctuate with those of the stream"* - Tracy I. Storer, 1925

Several past and ongoing activities have changed the watersheds upon which Foothill Yellow-legged Frogs depend, and many interact with each other exacerbating their adverse impacts. With such an expansive range in California, the degree and severity of these impacts on the species often vary by location. To the extent feasible based on the best scientific information available, those differences are discussed below.

Dams, Diversions, and Water Operations

Foothill Yellow-legged Frogs evolved in a Mediterranean climate with predictable cool, wet winters and hot, dry summers~~,~~; ~~with~~ their life cycle is adapted to these conditions. In California and other areas with a Mediterranean climate, human demands for water are at the highest when runoff and precipitation are lowest, and annual water supply varies significantly but always follows the general pattern of peak discharge declining to baseflow in the late spring or summer (Grantham et al. 2010). The Foothill Yellow-legged Frog's life cycle depends on this discharge pattern and the specific habitat conditions it produces (see the Breeding and Rearing Habitat section). Dams are ubiquitous, but not evenly distributed, in California. Figure 16 depicts the locations of dams under the jurisdiction of the Army Corps of Engineers (ACOE) and the California Department of Water Resources (DWR). Figure 17 depicts the number of surface diversions per PLSS section within the Foothill Yellow-legged Frog's range (eWRIMS 2019).

Dam operations frequently change the amount and timing of water availability; its temperature, depth, and velocity; and its capacity to transport sediment ~~transport~~ and alter channel morphology ~~altering functions~~, all of which can result in dramatic consequences on the Foothill Yellow-legged Frog's ability to survive and successfully reproduce. Several studies comparing Foothill Yellow-legged Frog populations in regulated and unregulated reaches within the same watershed investigate potential dam-effects. These studies demonstrated that dams and their operations can result in several factors that contribute to population declines and possible extirpation. These factors include confusing breeding cues, scouring and stranding of egg masses and tadpoles, reduced quality and quantity of breeding and rearing habitat, reduced tadpole growth rate, barriers to gene flow, and establishment and spread of non-native species (Hayes et al. 2016). In addition, as previously discussed in the Population Structure and Genetic Diversity section, subpopulations of Foothill Yellow-legged Frogs on regulated rivers are more isolated, and the

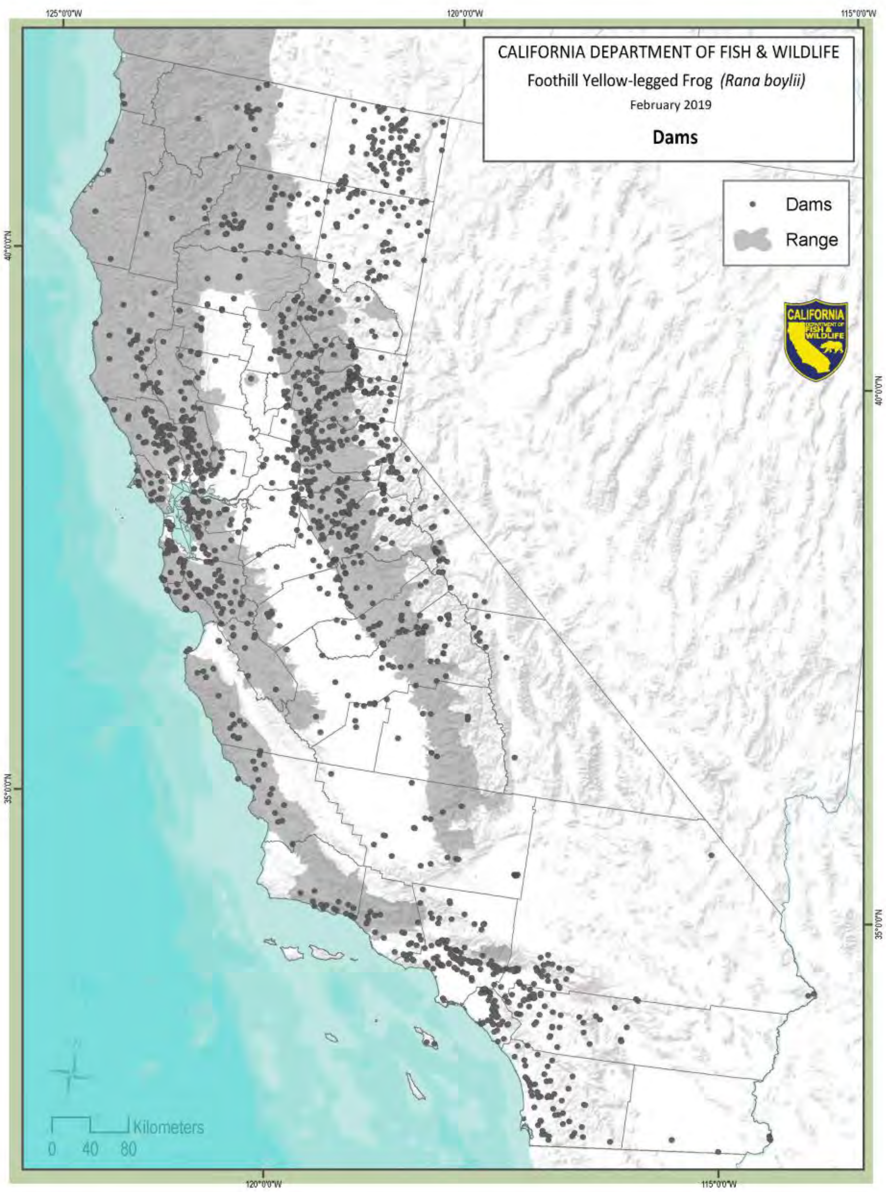

Figure 16. Locations of ACOE and DWR jurisdictional dams (DWR, FRS)

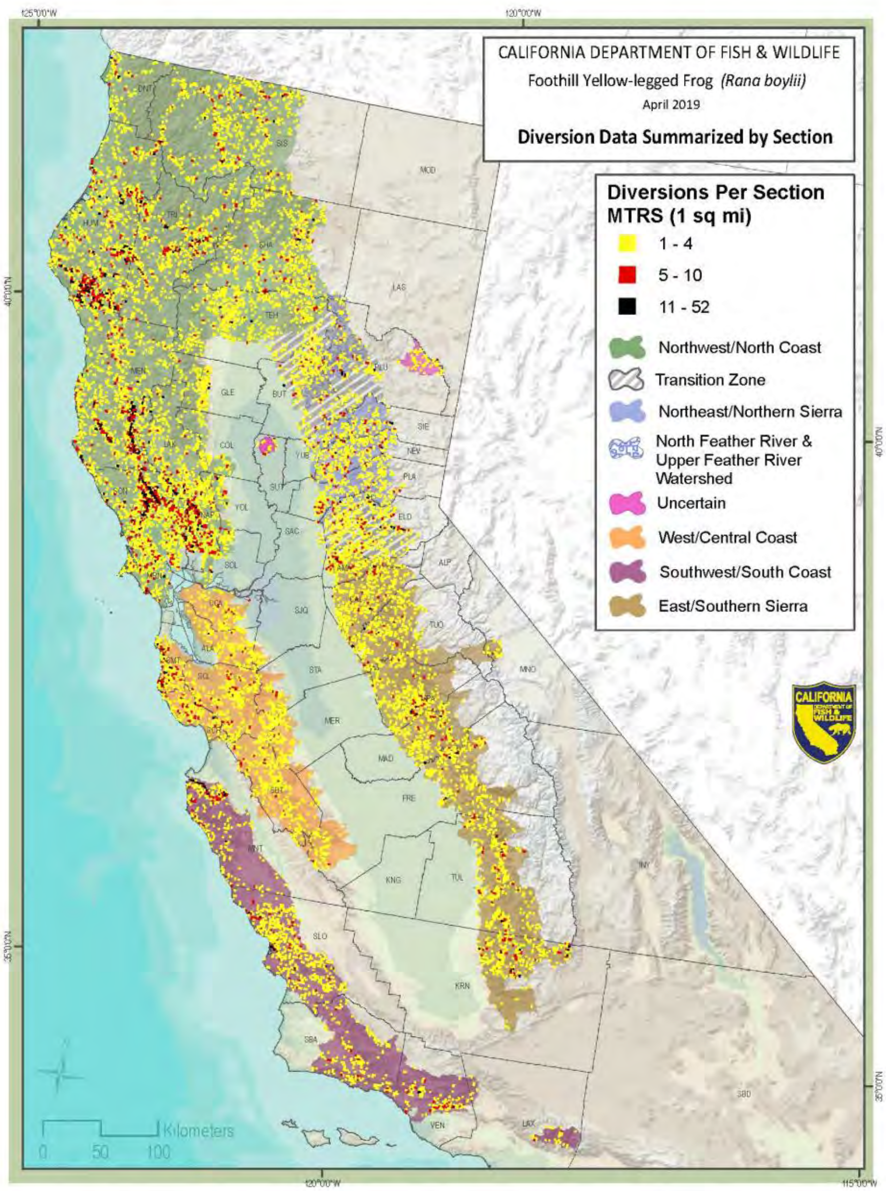

Figure 17. Number of surface water diversions per Public Lands Survey System section within the Foothill Yellow-legged Frog's range in California (eWRIMs)

type of water operations (hydropeaking vs. bypass flows) significantly affects the degree of gene flow loss among them (Peek 2011, 2018). Figure 18 depicts the locations of hydroelectric power plants.

As discussed in the Seasonal Activity and Movements section, cues for Foothill Yellow-legged Frogs to start breeding appear to involve water temperature and velocity, two features altered by dams. Dam operations typically result in reduced flows that are more stable over the course of a year than unimpaired conditions, and dam managers are frequently required to maintain thermally appropriate water temperatures and flows for cold-water-adapted salmonids (USFWS and Hoopa Valley Tribe 1999, Wheeler et al. 2014). For example, late-spring and summer water temperatures on the mainstem Trinity River below Lewiston Dam have been reported to be up to 10°C (20°F) cooler than average pre-dam temperatures, while average winter temperatures are slightly warmer (USFWS and Hoopa Valley Tribe 1999). As a result, Foothill Yellow-legged Frogs breed later on the mainstem Trinity River compared to six nearby tributaries, and some mainstem reaches may never attain the minimum required temperature for breeding (Wheeler et al. 2014, Snover and Adams 2016). In addition, annual discharges past Lewiston Dam have been 10-30% of pre-dam flows and do not mimic the natural hydrograph (Lind et al. 1996).

Aseasonal discharges from dams occur for several reasons including increased flow in late-spring and early summer to facilitate outmigration of salmonids, channel maintenance pulse flows, short-duration releases for recreational whitewater boating, rapid reductions after a spill (uncontrolled flows released down a spillway when reservoir capacity is exceeded) to retain water for power generation or water supply later in the year, peaking flows for hydroelectric power generation, and sustained releases to maintain the seismic integrity of the dam (Lind et al. 1996, Jackman et al. 2004, Kupferberg et al. 2011b, Kupferberg et al. 2012, Snover and Adams 2016). The results of a Foothill Yellow-legged Frog population viability analysis (PVA) suggest that the likelihood a population will persist is very sensitive to early life stage mortality; the 30-year probability of extinction increases significantly with high levels of egg or tadpole scouring or stranding (Kupferberg et al. 2009c). For instance, in 1991 and 1992, all egg masses laid before high flow releases to encourage outmigration of salmonids on the Trinity River were scoured away (Lind et al. 1996). According to the PVA, even a single annual pulse flow such as this or for recreational boating, can result in a three- to five-fold increase in the 30-year extinction risk based on amount of tadpole mortality experienced (Kupferberg et al. 2009c). Management after natural spills can also lead to substantial mortality. For example, in 2006, Foothill Yellow-legged Frogs on the North Fork Feather River bred during a prolonged spill, and the rapid recession below Cresta Dam that followed stranded and desiccated all the eggs laid (Kupferberg et al. 2009b). Rapid flows can also increase predation risk if tadpoles are forced to seek shelter under rocks where crayfish and other invertebrate predators are more common or if they are displaced into the water column where their risk of predation by fish is greater (Ibid.).

The overall reduction of flows and frequency of large winter floods below dams can produce extensive changes to Foothill Yellow-legged Frog habitat quality. They reduce the formation of river bars that are regularly used as breeding habitat, and they create deeper and steeper channels with less complexity and fewer warm, calm, shallow edgewater habitats for tadpole rearing (Lind et al. 1996, Wheeler and Welsh 2008, Kupferberg et al. 2011b, Wheeler et al. 2014). For example, 26 years after construction of

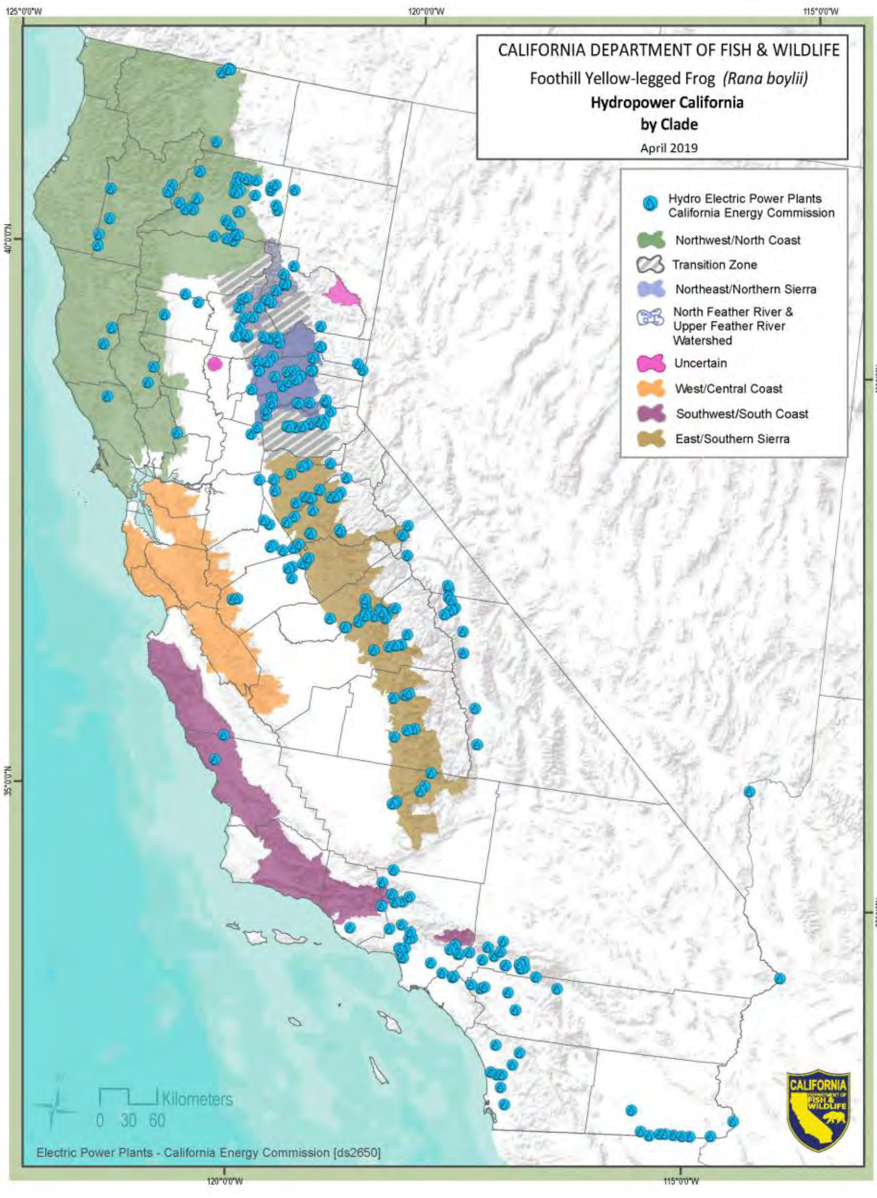

Figure 18. Locations of hydroelectric power generating dams (BIOS)

the Lewiston Dam on the Trinity River, habitat changes in a 63 km (39 mi) stretch from the dam downstream were evaluated (Lind et al. 1996). Riparian vegetation went from covering 30% of the riparian area pre-dam to 95% (Ibid.). Additionally, river bars made up 70% of the pre-dam riparian area compared to 4% post-dam, amounting to a 94% decrease in available Foothill Yellow-legged Frog breeding habitat (Ibid.).

Several features of riverine habitat below dams can decrease tadpole growth rate and other measures of fitness. As ectotherms, Foothill Yellow-legged Frogs require temperatures that support their metabolism, food conversion efficiency, growth, and development, and these temperatures may not be reached until late in the season, or not at all, when the water released is colder than their lower thermal limit (Kupferberg et al. 2011a, Catenazzi and Kupferberg 2013, Wheeler et al. 2014). Colder temperatures and higher flows reduce time spent feeding and efficiency at food assimilation, resulting in slower growth and development (Kupferberg et al. 2011a,b; Catenazzi and Kupferberg 2018). Large bed-scouring winter floods promote greater *Cladophora glomerate* blooms, the filamentous green alga that dominates primary producer biomass during the tadpole rearing season (Power et al. 2008, Kupferberg et al. 2011a). The period of most rapid tadpole growth often coincides with blooms of highly nutritious and more easily assimilated epiphytic diatoms, so reduced flows can have food-web impacts on tadpole growth and survival (Power et al. 2008, Kupferberg et al. 2011a, Catenazzi and Kupferberg 2018). In addition, colder temperatures and fluctuating summer flows, such as those released for hydroelectric power generation, can reduce the amount of algae available for grazing and can change the algal assemblage to one dominated by mucilaginous stalked diatoms like *Didymosphenia* ~~*geminate*~~ *geminata* that have low nutritional value (Spring Rivers Ecological Sciences 2003, Kupferberg et al 2011a, Furey et al. 2014). Altered temperatures, flows, and food quality can contribute to slower growth and development, longer time to metamorphosis, smaller size at metamorphosis, and reduced body condition, which adversely impact fitness (Kupferberg et al. 2011b, Catenazzi and Kupferberg 2018).

As discussed in more detail in the Population Structure and Genetic Diversity section, both are strongly affected by river regulation (Peek 2011, 2018; Stillwater Sciences 2012). Foothill Yellow-legged Frogs primarily use watercourses as movement corridors, so the reservoirs created behind dams are often uninhabitable and represent barriers to gene flow (Bourque 2008; Peek 2011, 2018). This decreased connectivity can lead to loss of genetic diversity, inducing a species' ability to adapt to changing conditions (Palstra and Ruzzante 2008).

Decreased winter discharge below dams facilitates establishment and expansion of invasive bullfrogs, whose tadpoles require overwintering and are not well-adapted to flooding events (Lind et al. 1996, Doubledee et al. 2003). Where they occur, bullfrogs tend to dominate areas more altered by dam operations than less impaired areas that support a higher proportion of native species (Moyle 1973, Fuller et al. 2011). In addition to downstream effects, the reservoirs created behind dams directly destroy lotic (flowing) Foothill Yellow-legged Frog habitat, typically do not retain natural riparian communities due to fluctuating water levels, are often managed for human activities not compatible with the species' needs, and act as a source of introduced species upstream and downstream (Brode and Bury 1984, PG&E 2018). Moyle and Randall (1998) identified characteristics of sites with low native biodiversity in the Sierra Nevada foothills; they were often drainages that had been dammed and

diverted in lower- to middle-elevations and dominated by introduced fishes and bullfrogs. Even small-scale operations can have significant effects. Some farming operations divert water during periods of high flows and store it in small impoundments for use during low flow-high need times; these ponds can serve as sources for introduced species like bullfrogs to spread into areas where the habitat would otherwise be unsuitable (Kupferberg 1996b).

The mechanisms described above result in the widespread pattern of greater Foothill Yellow-legged Frog density in unregulated rivers and in reaches far enough downstream of a dam to experience minimal effects from it (Lind et al. 1996, Kupferberg 1996a, Bobzien and DiDonato 2007, Peek 2011). Abundance in unregulated rivers averages five times greater than population abundance downstream of large dams (Kupferberg et al. 2012). Figure 19 depicts a comprehensive collection of egg mass density data where at least four years of surveys have been undertaken, showing much lower abundance in regulated (S. Kupferberg pers. comm. 2019). In California, Foothill Yellow-legged Frog presence is associated with an absence of dams or with only small dams far upstream (Lind 2005, Kupferberg et al. 2012). Hydroelectric power generation from Sierra Nevada rivers accounts for nearly half its statewide production and about 9% of all electrical power used in California (Dettinger et al. 2018). Every major stream below 600 m (1968 ft) in the Sierra Nevada has at least one large reservoir (≥ 0.12 km^3 [100,000 ac-ft]), and many have multiple medium and small ones (Hayes et al. 2016). Because of this, Catenazzi and Kupferberg (2017) posit that the dam-effect on Foothill Yellow-legged Frog populations is likely greater in the Sierra Nevada than the Coast Range because dams are more often constructed in a series along a river in the former and spaced close enough together such that suitable breeding temperatures may never occur in the intervening reaches.

Pathogens and Parasites

Perhaps the most widely recognized amphibian disease is chytridiomycosis, which is caused by the fungal pathogen *Batrachochytrium dendroabatidis* (Bd). Implicated in the decline of over 500 amphibian species, including 90 presumed extinctions, it represents the greatest recorded loss of biodiversity attributable to a disease (Scheele et al. 2019). The global trade in American Bullfrogs (primarily for food) is connected to the disease's spread because the species can persist with low-level Bd infections without developing chytridiomycosis (Yap et al. 2018). Previous studies suggested Foothill Yellow-legged Frogs may not be susceptible to Bd-associated mass mortality; skin peptides strongly inhibited growth of the fungus in the lab, and the only detectable difference between Bd+ and Bd- juvenile Foothill Yellow-legged Frogs was slower growth (Davidson et al. 2007). At Pinnacles National Park in 2006, 18% of post-metamorphic Foothill Yellow-legged Frogs tested positive for Bd; all were asymptomatic and at least one Bd+ Foothill Yellow-legged Frog subsequently tested negative, demonstrating an ability to shed the fungus (Lowe 2009). However, recent studies have found historical evidence of Bd contributing to the extirpation of Foothill Yellow-legged Frogs in southern California, an acute die-off in 2013 in the Alameda Creek watershed, and another in 2018 in Coyote Creek (Adams et al. 2017a,b; Kupferberg and Catenazzi 2019). Evaluation of museum specimens indicates lower Bd prevalence (proportion of individuals infected) in Foothill Yellow-legged Frogs than most other co-occurring amphibians in southern California in the first part of the 20th century, but it spiked in the 1970s just prior to the last observation of an individual in 1977 (Adams et al. 2017b). Two museum specimens collected in 1966,

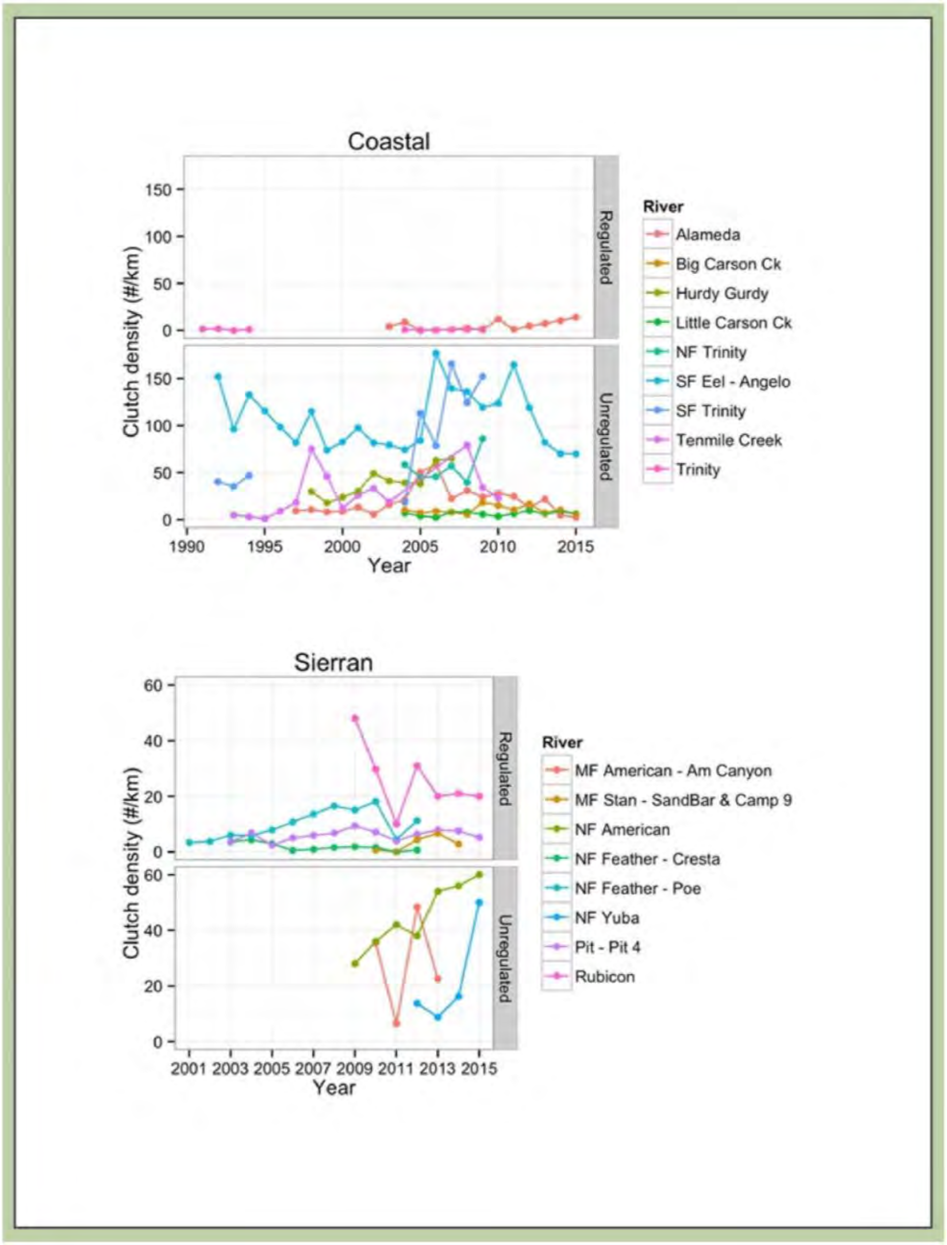

Figure 19. Foothill Yellow-legged Frog Egg mass density estimates along the coast from 1990-2015 and the Sierra Nevada from 2001-2015 from multiple studies compiled by S. Kupferberg (2019)

one from Santa Cruz County and the other from Alameda County, provide the earliest evidence of Bd in Foothill Yellow-legged Frogs in central California (Padgett-Flohr and Hopkins 2009). In contrast to the southern California results, Foothill Yellow-legged Frogs possessed the highest Bd prevalence among all amphibians tested in coastal Humboldt County in 2013 and 2014; however, zoospore (the aquatic dispersal agent) loads were well below the presumed lethal density threshold (Ecoclub Amphibian Group et al. 2016).

In addition to bullfrogs, the native Pacific Treefrog (*Pseudacris regilla*) seems immune to the lethal effects of chytridiomycosis, and owing to its broad ecological tolerances, more terrestrial lifestyle, and relatively large home range size and dispersal ability, the species is ubiquitous across California (Padgett-Flohr and Hopkins 2009). In a laboratory experiment, Bd-infected Pacific Treefrogs shed an average of 68 zoospores per minute, making them the prime candidate for spreading and maintaining Bd in areas where bullfrogs do not occur (Padgett-Flohr and Hopkins 2009, Reeder et al. 2012). In the wild, Pacific Treefrog populations persisted at 100% of sites in the Sierra Nevada (above 1500 m [4920 ft]) where a sympatric ranid species had been extirpated from 72% of its formerly occupied sites due to a Bd outbreak (Reeder et al. 2012). This is consistent with the results of a model that incorporated Bd habitat suitability, host availability, and invasion history in North America, which concluded west coast mountain ranges were at the greatest risk from the disease (Yap et al. 2018).

Several other pathogens and parasites have been encountered with Foothill Yellow-legged Frogs, but none have been ascribed to large-scale mortality events. Another fungus, a water mold (*Saprolegnia* sp.) carried by fish, is an important factor in amphibian embryo mortality in the Pacific Northwest (Blaustein et al. 1994, Kiesecker and Blaustein 1997). Fungal infections of Foothill Yellow-legged Frog egg masses, potentially from *Saprolegnia*, have been observed in the mainstem Trinity River (Ashton et al. 1997). *Saprolegnia* infection is more likely to occur in ponds and lakes, particularly if stocked by hatchery-raised fish into previously fishless areas and when frogs use communal oviposition sites, so it likely does not represent a major source of mortality in Foothill Yellow-legged Frogs (Blaustein et al. 1994, Kiesecker and Blaustein 1997). However, they may be more susceptible to *Saprolegnia* infection when exposed to other environmental stressors that compromise their immune defenses (Blaustein et al. 1994, Kiesecker and Blaustein 1997).

The trematode parasite *Ribeiroia ondatrae* is responsible for limb malformations in ranids (Stopper et al. 2002). *Ribeiroia ondatrae* was detected on a single Foothill Yellow-legged Frog during a study on malformations, but its morphology was normal (Kupferberg et al. 2009a). The results of the study instead linked malformations in Foothill Yellow-legged Frog tadpoles and young-of-year to the Anchor Worm (*Lernaea cyprinacea*), a parasitic copepod from Eurasia (Ibid.). Prevalence of malformations was low, under 4% of the population in both years of study, but there was a pattern of infected individuals metamorphosing at a smaller size, which as previously mentioned can have implications on fitness (Ibid.). Three other species of helminths (parasitic worms) were encountered during the study (*Echinostoma* sp., *Manodistomum* sp., and *Gyrodactylus* sp.); their relative impact on their hosts is unknown, but at least one Foothill Yellow-legged Frog had 700 echinostome cysts in its kidney (Ibid.). Bursey et al. (2010) discovered 13 species of helminths in and on Foothill Yellow-legged Frogs from

Humboldt County. Most are common in anurans, and some are generalists with multiple possible hosts, but studies on their impact on Foothill Yellow-legged Frogs are lacking (Ibid.).

Introduced Species

Species not native to an area, but introduced, can alter food webs and ecosystem processes through predation, competition, hybridization, disease transmission, and habitat modification. Native species lack evolutionary history with introduced species, and early life stages of native anurans are particularly susceptible to predation by aquatic non-native species (Kats and Ferrer 2003). Because introduced species often establish in highly modified habitats, it can be difficult to differentiate between impacts from habitat degradation and the introduced species (Fisher and Shaffer 1996). However, native amphibians have been frequently found successfully reproducing in heavily altered habitats when introduced species were absent, suggesting introduced species themselves can impose an appreciable adverse effect (Ibid.). Numerous introduced species have been documented to adversely impact Foothill Yellow-legged Frogs or are suspected of doing so.

American Bullfrogs were introduced to California from the eastern U.S. around the turn of the 20th century, likely in response to overharvest of native ranids by the frog-leg industry that accompanied the Gold Rush (Jennings and Hayes 1985). Nearly 50 years ago, Moyle (1973) reported that distributions of Foothill Yellow-legged Frogs and bullfrogs in the Sierra Nevada foothills were nearly mutually exclusive. He speculated that bullfrog predation and competition may be causal factors in their disparate distributions in addition to the habitat degradation from dams and diversions that facilitated the bullfrog invasion in the first place. In a study along the South Fork Eel River and one of its tributaries, Foothill Yellow-legged Frog abundance was nearly an order of magnitude lower in reaches where bullfrogs were well established (Kupferberg 1997a). At a site in Napa Valley, after bullfrogs were eradicated, Foothill Yellow-legged Frogs, among other native species, recolonized the area (J. Alvarez pers. comm. 2018). In a mesocosm experiment, Foothill Yellow-legged Frog survival in control enclosures measured half that of enclosures containing bullfrog and Foothill Yellow-legged Frog tadpoles, and they weighed approximately one-quarter lighter at metamorphosis (Kupferberg 1997a). The mechanism for these declines appeared to be the reduction of high quality algae by bullfrog tadpole grazing, as opposed to any behavioral or chemical interference (Ibid.). Adult bullfrogs, which can get very large (9.0-15.2 cm [3.5-6.0 in]), also directly consume Foothill Yellow-legged Frogs, including adults (Moyle 1973, Crayon 1998, Powell et al. 2016). Silver (2017) noted that she never heard Foothill Yellow-legged Frogs calling in areas with bullfrogs, which has implications for breeding success; she speculated the lack of vocalizations may have been a predator avoidance strategy.

Commented [SK1]: This is terrific!

As discussed briefly in the Pathogens and Parasites section, American Bullfrogs act as reservoirs and vectors of the lethal chytrid fungus. In museum specimens from both southern and central California, Bd was detected in bullfrogs before it was detected in Foothill Yellow-legged Frogs in the same area (Padgett-Flohr and Hopkins 2009, Adams et al. 2017b). During a die-off from chytridiomycosis that commenced in 2013, Bd prevalence and load in Foothill Yellow-legged Frogs was positively predicted by bullfrog presence (Adams et al. 2017a). A similar die-off in 2018 from a nearby county appears to be related to transmission by bullfrogs as well (Kupferberg and Catenazzi 2019). In addition, male Foothill

Yellow-legged Frogs have been observed amplexing female bullfrogs, which may not only constitute wasted reproductive effort but could serve to increase their likelihood of contracting Bd (Lind et al. 2003a). In fact, adult males were more likely to be infected with Bd than females or juveniles during the recent die-off in Alameda Creek (Adams et al. 2017a). African Clawed Frogs (*Xenopus laevis*) have also been implicated in the spread of Bd in California because like bullfrogs, they are asymptomatic carriers (Padgett-Flohr and Hopkins 2009). However, African Clawed-Frog distribution only minimally overlaps with the Foothill Yellow-legged Frog's range unlike the widespread bullfrog (Stebbins and McGuinness 2012).

Hayes and Jennings (1986) observed a negative association between the abundance of introduced fish and Foothill Yellow-legged Frogs. Rainbow trout (*Onchorynchus mykiss*) and green sunfish (*Lepomis cyanellus*) are suspected of destroying egg masses (Van Wagner 1996). Bluegill sunfishes (*L. macrochirus*) are likely predators; in captivity when offered eggs and tadpoles of two ranid species, they consumed both life stages but a significantly greater number of tadpoles (Werschkul and Christensen 1977). Common hatchery-stocked fish like brook (*Salvelinus fontinalis*) and rainbow trout commonly carry ~~of~~ *Saprolegnia* (Blaustein et al. 1994). In addition, presence of non-native fish can facilitate bullfrog invasions by reducing the density of macroinvertebrates that prey on their tadpoles (Adams et al. 2003). Foothill Yellow-legged Frog tadpoles raised from eggs from sites with and without smallmouth bass (*Micropterus dolomieu*) did not differ in their responses to exposure to the non-native, predatory bass and a native, non-predatory fish (Paoletti et al. 2011). This result suggests that Foothill Yellow-legged Frogs have not yet evolved a recognition of bass as a threat, which makes them more vulnerable to predation (Ibid.).

Introduced into several areas within the Coast Range and Sierra Nevada, signal crayfish have been recorded preying on Foothill Yellow-legged Frog egg masses and are suspected of preying on their tadpoles based on observations of tail injuries that looked like scissor snips (Riegel 1959, Wiseman et al. 2005). The introduced red swamp crayfish (*Procambarus clarkii*) likely also preys on Foothill Yellow-legged Frogs. Because Foothill Yellow-legged Frogs evolved with native crayfish in northern California, individuals from those areas may more effectively avoid crayfish predation than in other parts of the state where they are not native (Riegel 1959, USFWS 1998, Kats and Ferrer 2003). The Foothill Yellow-legged Frog's naiveté ~~naivety~~ to crayfish was demonstrated in a study that showed they did not change behavior when exposed to signal crayfish chemical cues, but once the crayfish was released and consuming Foothill Yellow-legged Frog tadpoles, the survivors, likely reacting to chemical cues from dead tadpoles, did respond (Kerby and Sih 2015).

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Sedimentation

Several anthropogenic activities, some of which are described in greater detail below, can artificially increase sedimentation into waterways occupied by Foothill Yellow-legged Frogs and adversely impact biodiversity (Moyle and Randall 1998). These activities include but are not limited to mining, agriculture, overgrazing, timber harvest, and poorly constructed roads (Ibid.). Increased fine sediments can substantially degrade Foothill Yellow-legged Frog habitat quality. Heightened turbidity decreases light penetration that phytoplankton and other aquatic plants require for photosynthesis (Cordone and Kelley

1961). When silt particles fall out of the water column, they can destroy algae by covering the bottom of the stream (Ibid.). Algae are not only important for Foothill Yellow-legged Frog tadpoles as forage but also oxygen production (Ibid.). Sedimentation may impede attachment of egg masses to substrate (Ashton et al. 1997). The effect of silt accumulation on embryonic development is unknown, but it does make them less visible, which could decrease predation risk (Fellers 2005). Fine sediments can fill interstitial spaces between rocks that tadpoles use for shelter from high velocity flows and cover from predators and that serve as sources for aquatic invertebrate prey for post-metamorphic Foothill Yellow-legged Frogs (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b).

Mining

Current mining practices, as well as legacy effects from historical mining operations, may adversely impact Foothill Yellow-legged Frogs through contaminants, direct mortality, habitat destruction and degradation, and behavioral disruption. While mercury in streams can result from atmospheric deposition, storm-induced runoff of naturally occurring mercury, agricultural runoff, and geothermal springs, runoff from historical mine sites mobilizes a significant amount of mercury (Foe and Croyle 1998, Alpers et al. 2005, Hothem et al. 2010). Beginning in the mid-1800s, extensive mining occurred in the Coast Range to supply mercury for gold mining in the Sierra Nevada, causing widespread contamination of both mountain ranges and the rivers in the Central Valley (Foe and Croyle 1998). Studies on Foothill Yellow-legged Frog tissues collected from the Cache Creek (Coast Ranges) and Greenhorn Creek (Sierra Nevada) watersheds revealed mercury bioaccumulation concentrations as high as 1.7 and 0.3 µg/g (ppm), respectively (Alpers et al. 2005, Hothem et al. 2010). For context, the U.S. Environmental Protection Agency's mercury criterion for issuance of health advisories for fish consumption is 0.3 µg/g; concentrations exceeded this threshold in Foothill Yellow-legged Frog tissues at 62% of sampling sites in the Cache Creek watershed (Hothem et al. 2010). Bioaccumulation of this powerful neurotoxin can cause deleterious impacts on amphibians including inhibited growth, decreased survival to metamorphosis, increased malformations, impaired reproduction, and other sublethal effects (Zillioux et al. 1993, Unrine et al. 2004). In a study measuring Sierra Nevada watershed health, Moyle and Randall (1998) reportedly found very low biodiversity in streams that were heavily polluted by acidic water leaching from historical mines. Acidic drainage measured as low as 3.4 pH from some mined areas in the northern Sierra Nevada (Alpers et al. 2005).

Widespread suction dredging for gold occurred in the Foothill Yellow-legged Frog's California range until enactment of a moratorium on issuing permits in 2009 (Hayes et al. 2016). Suction dredging vacuums up the contents of the streambed, passes them through a sluice box to separate the gold, and then deposits the tailings on the other side of the box (Harvey and Lisle 1998). While most habitat disturbance is localized and minor, it can be especially detrimental if it degrades or destroys breeding and rearing habitat through direct disturbance or sedimentation (Ibid.). In addition, this activity can lead to direct mortality of early life stages through entrainment, and those eggs and tadpoles that do survive passing through the suction dredge may experience greater mortality due to subsequent unfavorable physiochemical conditions and possible increased predation risk (Ibid.). Suction dredging can also reduce the availability of invertebrate prey, although this impact is typically short-lived (Ibid.). Suction dredging alters stream morphology, and relict tailing ponds can serve as breeding habitat for bullfrogs in areas

that would not normally support them (Fuller et al. 2011). However, in some areas these mining holes have reportedly benefited Foothill Yellow-legged Frogs by creating cool persistent pools that adult females appeared to prefer at one Sierra Nevada site (Van Wagner 1996). Senate Bill 637 (2015) directs the Department to work with the State Water Resources Control Board (SWRCB) to develop a statewide water quality permit that would authorize the use of vacuum or suction dredge equipment in California under conditions set forth by the two agencies. SWRCB staff, in coordination with Department staff, are in the process of collecting additional information to inform the next steps that will be taken by the SWRCB (SWRCB 2019).

Instream aggregate (gravel) mining continues today and can have similar impacts to suction dredge mining by removing, processing, and relocating stream substrates (Olson and Davis 2009). This type of mining typically removes bars used as Foothill Yellow-legged Frog breeding habitat and reduces habitat heterogeneity by creating flat wide channels (Kupferberg 1996a). Typically, when listed salmonids are present, mining must be conducted above the wetted edge, but this practice can create perennial off-channel bullfrog breeding ponds (M. van Hattem pers. comm. 2018).

Agriculture

Direct loss of Foothill Yellow-legged Frog habitat from wildland conversion to agriculture is rare because the typically rocky riparian areas they inhabit are usually not conducive to farming, but removal of riparian vegetation directly adjacent to streams for agriculture is more common and widespread. The U.S. Department of Agriculture classifies 3.9 million ha (9.6 million ac) in California as cropland, which amounts to less than 10% of the state's land area, and 70% of this occurs in the Central Valley between Redding and Bakersfield (Martin et al. 2018). In addition, several indirect impacts can adversely affect Foothill Yellow-legged Frogs at substantial distances from agricultural operations such as effects from runoff (sediments and agrochemicals), drift and deposition of airborne pollutants, water diversions, and creation of novel habitats like impoundments that facilitate spread of detrimental non-native species. As sedimentation and introduced species impacts were previously discussed, this section instead focuses on the other possible adverse impacts.

Agrochemicals

Many species of amphibians, particularly ranids, have experienced declines throughout California, but the most dramatic declines have occurred in the Sierra Nevada east of the San Joaquin Valley where 60% of the total pesticide usage in the state was sprayed (Sparling et al. 2001). Agrochemicals applied to crops in the Central Valley can volatilize and travel in the atmosphere and deposit in higher elevations (LeNoir et al. 1999). Pesticide concentrations diminish as elevations increase in the lower foothills but change little from 533 to 1,920 m (1,750-6,300 ft), which coincides with the Foothill Yellow-legged Frog's elevational range (Ibid). Foothill Yellow-legged Frog absence at historically occupied sites in California significantly correlated with agricultural land use within 5 km (3 mi), and a positive relationship exists between Foothill Yellow-legged Frog declines and the amount of upwind agriculture, suggesting airborne agrochemicals may be a contributing factor (Figure 20; Davidson et al. 2002). Cholinesterase-inhibitors (most organophosphates and carbamates), which disrupt nerve impulse transmission, were

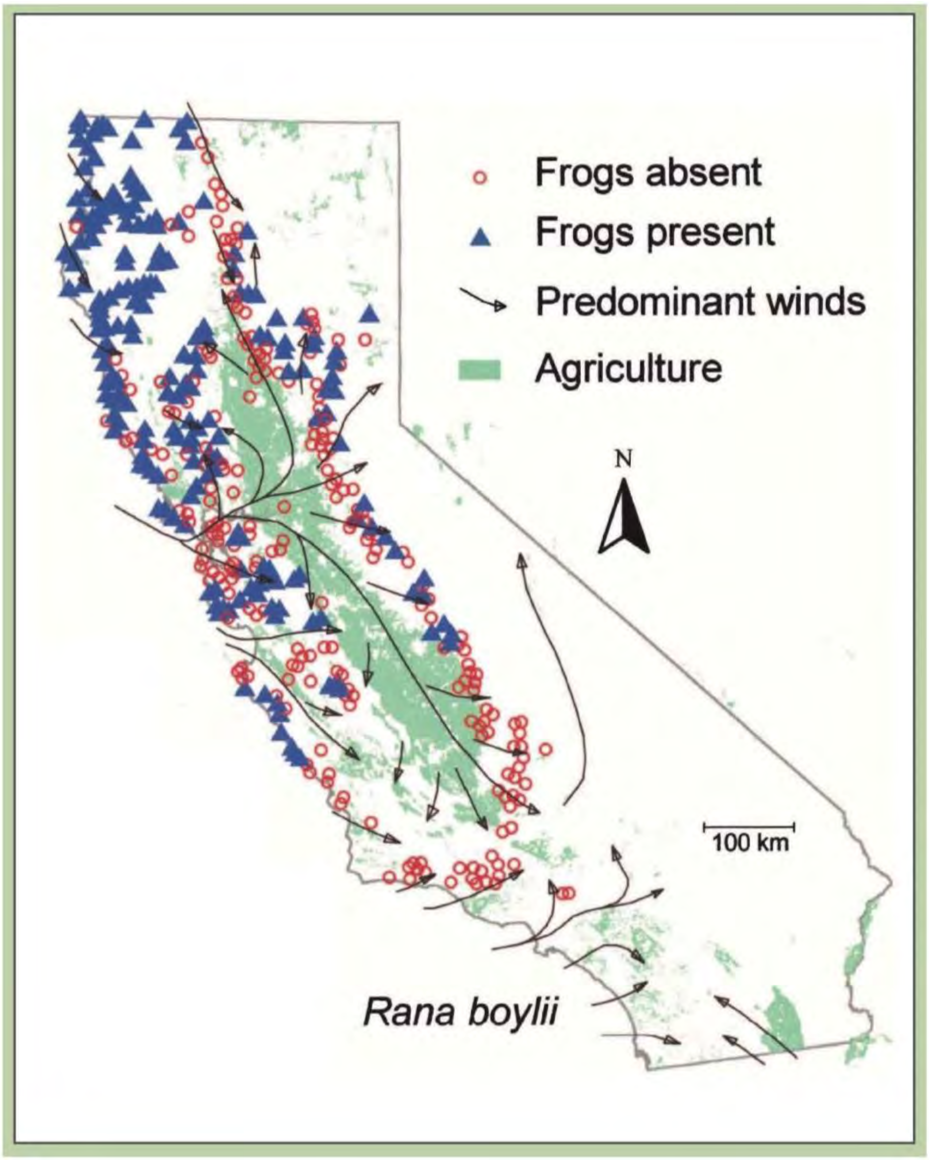


Figure 20. Relationship of Foothill Yellow-legged Frog occupancy to agriculture from Davidson et al. (2002)

more strongly associated with population declines than other pesticide types (Davidson 2004). Olson and Davis (2009) and Lind (2005) also reported a negative correlation between Foothill Yellow-legged Frog presence and proximity and quantity of nearby agriculture in Oregon and across the species' entire range, respectively.

Lethal and sublethal effects of agrochemicals on amphibians can take two general forms: direct toxicity and food-web effects. Sublethal doses of agrochemicals can interact with other environmental stressors to reduce fitness. Foothill Yellow-legged Frog tadpoles showed significantly greater vulnerability to the lethal and sublethal effects of carbaryl than Pacific Treefrogs (Kerby and Sih 2015). An inverse relationship exists between carbaryl concentration and Foothill Yellow-legged Frog activity, and their 72-h LC_{50} (concentration at which 50% die) measured one-fifth that of Pacific Treefrogs (Ibid.). Carbaryl slightly decreased Foothill Yellow-legged Frog development rate, but it significantly increased susceptibility to predation by signal crayfish despite nearly no mortality in the pesticide- and predator-only treatments (Ibid.). Sparling and Fellers (2009) also found Foothill Yellow-legged Frogs were significantly more sensitive to pesticides (chlorpyrifos and endosulfan in this study) than Pacific Treefrogs; their 96-hr LC_{50} was nearly five-times less than for treefrogs. Endosulfan was nearly 121 times more toxic to Foothill Yellow-legged Frogs than chlorpyrifos, and water samples from the Sierra Nevada have contained endosulfan concentrations within their lethal range and sometimes greater than the LC_{50} for the species (Ibid.). Sublethal effects included smaller body size, slower development rate, and increased time to metamorphosis (Ibid.). Sparling and Fellers (2007) determined the organophospates chlorpyrifos, malathion, and diazinon can harm Foothill Yellow-legged Frog populations, and their oxon derivatives (the resultant compounds once they begin breaking down in the body) were 10 to 100 times more toxic than their respective parental forms.

Extrapolating the results of studies on other ranids to Foothill Yellow-legged Frogs should be undertaken with caution; however, those studies can demonstrate additional potential adverse impacts of exposure to agrochemicals. Relyea (2005) discovered that Roundup®, a common herbicide, could cause rapid and widespread mortality in amphibian tadpoles via direct toxicity, and overspray at the manufacturer's recommended application concentrations would be highly lethal. Atrazine, another common herbicide, has been implicated in disrupting reproductive processes in male Northern Leopard Frogs (*Rana pipiens*) by slowing gonadal development, inducing hermaphroditism, and even oocyte (egg) growth (Hayes et al. 2003). However, recent research on sex reversal in wild populations of Green Frogs (*R. clamitans*) suggests it may be a relatively common natural process unrelated to environmental contaminants, requiring more research (Lambert et al. 2019). Malathion, a common organophosphate insecticide, that rapidly breaks down in the environment, applied at low concentrations caused a trophic cascade that resulted in reduced growth and survival of two species of ranid tadpoles (Relyea and Diecks 2008). Malathion caused a reduction in the amount of zooplankton, which resulted in a bloom of phytoplankton and an eventual decline in periphyton, an important food source for tadpoles (Ibid.). In contrast, Relyea (2005) found that some insecticides increased amphibian tadpole survival by reducing their invertebrate predators. Runoff from agricultural areas can contain fertilizers that input nutrients into streams and increase productivity, but they can also result in harmful algal blooms (Cordone and

Kelley 1961). In addition, exposure to pesticides can result in immunosuppression and reduce resistance to the parasites that cause limb malformations (Kiesecker 2002, Hayes et al. 2006).

Cannabis

An estimated 60-70% of the cannabis (*Cannabis indica* and *C. sativa*) used in the U.S. from legal and illegal sources is grown in California, and most comes from the Emerald Triangle, an area comprised of Humboldt, Mendocino, and Trinity counties (Ferguson 2019). Small-scale illegal cannabis farms have operated in this area since at least the 1960s but have expanded rapidly, particularly trespass grows on public land primarily by Mexican cartels, since the passage of the Compassionate Use Act in 1996 (Mallery 2010, Bauer et al. 2015). Like other forms of agriculture, it involves clearing the land, diverting water, and using herbicides and pesticides; however, in addition, many of these illicit operations use large quantities of fertilizers and highly toxic banned pesticides to kill anything that may threaten the crop, and they leave substantial amounts of non-biodegradable trash and human excrement (Mallery 2010, Thompson et al. 2014, Carah et al. 2015).

Measurements of environmental impacts of illegal cannabis grows have been hindered by the difficult and dangerous nature of accessing many of these sites; however, some analyses have been conducted, often using aerial images and geographic information systems (GIS). An evaluation of 54% of watersheds within and bordering Humboldt County revealed that while cannabis grow sites are generally small (< 0.5 ha [1.2 ac]) and comprised a tiny fraction of the study area (122 ha [301 ac]), they were widespread (present in 83% of watersheds) but unevenly distributed, indicating impacts are concentrated in certain watersheds (Butsic and Brenner 2016, Wang et al. 2017). The results also showed that 68% of grows were > 500 m (0.3 mi) from developed roads, 23% were located on slopes steeper than 30%, and 5% were within 100 m (328 ft) of critical habitat for threatened salmonids (Butsic and Brenner 2016). These characteristics suggest wildlands adjacent to cannabis cultivations are at heightened risk of habitat fragmentation, erosion, sedimentation, landslides, and impacts to waterways critical to imperiled species (Ibid.).

A separate analysis in the same general area estimated potentially significant impacts from water diversions alone. Cannabis requires a substantial amount of water during the growing season, so it is often cultivated near sources of perennial surface water for irrigation, commonly diverting from springs and headwater streams (Bauer et al. 2015). In the least impacted of the study watersheds, Bauer et al. (2015) calculated that diversions for cannabis cultivation could reduce the annual seven-day low flow by up to 23%, and in some of the heavily impacted watersheds, water demands for cannabis could exceed surface water availability. If not regulated carefully, cannabis cultivation could have substantial impacts on sensitive aquatic species like Foothill Yellow-legged Frogs in watersheds in which it is concentrated.

For context, cannabis cultivation was responsible for approximately 1.1% of forest cover lost within study watersheds in Humboldt County from 2000 to 2013, while timber harvest accounted for 53.3% (Wang et al. 2017). Cannabis requires approximately two times as much water per day as wine grapes, the other major irrigated crop in the region (Bauer et al. 2015). Impacts from cannabis cultivation have been observed by Foothill Yellow-legged Frog researchers working on the Trinity River and South Fork

Eel River in the form of lower flows in summer, increased egg stranding, and more algae earlier in the season in recent years (S. Kupferberg and M. Power pers. comm. 2015; D. Ashton pers. comm. 2017; S. Kupferberg, M. van Hattem, and W. Stokes pers. comm. 2017). In addition, Gonsolin (2010) reported illegal cannabis cultivations on four headwater streams that drained into his study area along Coyote Creek, three of which were occupied by Foothill Yellow-legged Frogs. The cultivators had removed vegetation adjacent to the creeks, terraced the slopes, diverted water, constructed small water impoundments, poured fertilizers directly into the impoundments, and applied herbicides and pesticides, as evidenced by leftover empty containers littering the site.

Commercial sale of cannabis for recreational use became legal in California on January 1, 2018, through passage of the Control, Regulate and Tax Adult Use of Marijuana Act (2016), and with it an environmental permitting system and habitat restoration fund was established. The number of applications for temporary licenses per watershed is depicted in Figure 21. Two of the expected outcomes of passage of this law were that the profit-margin on growing cannabis would fall to the point that it would discourage illegal trespass grows and move the bulk of the cultivation out of remote forested areas into existing agricultural areas like the Central Valley (CSOS 2016). However, until cannabis is legalized at the federal level, these results may not occur since banks are reluctant to work with growers due to federal prohibitions subjecting them to prosecution for money laundering (ABA 2019). Additional details on cannabis permitting at the state level can be found under the Existing Management section.

Vineyards

Vineyard operators historically built on-stream dams and removed almost all the riparian vegetation to make room for vines and for ease of irrigation (M. van Hattem pers. comm. 2019). They still divert a substantial amount of water for irrigation, and they build on- and off-stream impoundments that support bullfrogs (Ibid.). The acreage of land planted in wine grapes in California began rising dramatically in the 1970s and now accounts for 90% of wine produced in the U.S. (Geisseler and Horwath 2016, Alston et al. 2018). The number of wineries in California rose from approximately 330 to nearly 2,500 between 1975 and 2006; however, expansion slowed and has reversed slightly recently with 24,300 ha (60,000 ac), or 6.5% of total area planted, removed between 2015 and 2017 (Volpe et al. 2010, CDFA 2018). In 2015, 347,000 ha (857,000 ac) were planted in grapes with 70% located in the San Joaquin Valley; 66%, 21%, and 13% were planted in wine, raisin, and table grapes, respectively (Alston et al. 2018).

Expansion of wineries in the coastal counties converted natural areas such as oak woodlands and forests to vineyards (Merenlender 2000, Napa County 2010). The area of Sonoma County covered in grapes increased by 32% from 1990 to 1997, and 42% of these new vineyards were planted above 100 m (328 ft) with 25% on slopes greater than 18% (Merelender 2000). For context, only 18% of vineyards planted before 1990 occurred above 100 m (328 ft) and less than 6% on slopes greater than 18% (Ibid.). This conversion took place on approximately 773 ha (1,909 ac) of conifer and dense hardwood forest, 149 ha (367 ac) of shrubland, and 2,925 ha (7,229 ac) of oak grassland savanna (Ibid.).

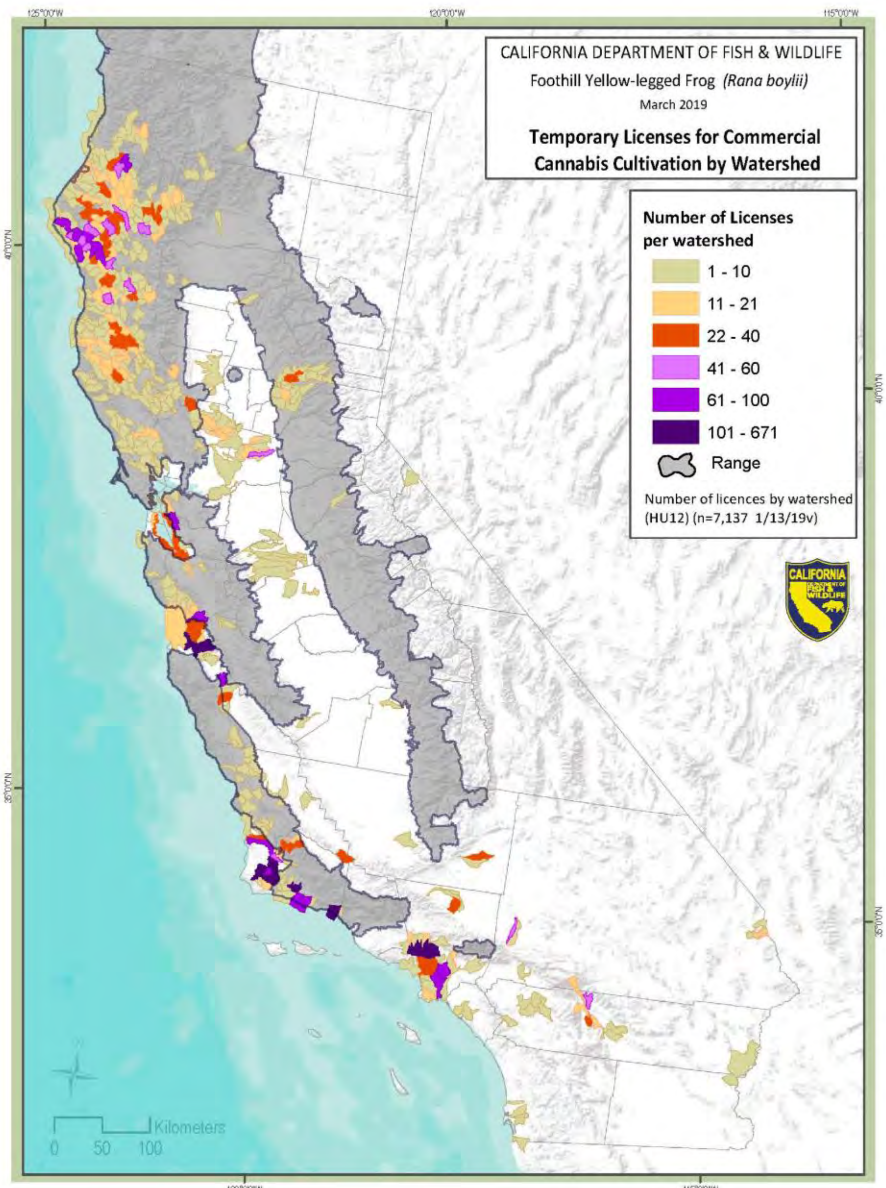


Figure 21. Cannabis cultivation temporary licenses by watershed in California (CDFA, NHD)

Recent expansion of oak woodland conversion to vineyards in Napa County was highest in its eastern hillsides (Napa County 2010). The County estimates that 1,085 and 1,240 ha (2,682-3,065 ac) of woodlands will be converted to vineyards between 2005 and 2030 (Ibid.). For context, 297 ha (733 ac) were converted from 1992 to 2003 (Ibid.). In addition, wine grapes were second only to almonds in terms of overall quantity of pesticides applied in California in 2016, but the quantity per unit area (2.9 kg/ha [2.6 lb/ac]) was 160% greater for the wine grapes (CDPR 2018). Vineyard expansion into hillsides has continued into sensitive headwater areas, and like cannabis cultivation, even small vineyards can have substantial impacts on Foothill Yellow-legged Frog habitat through sedimentation, water diversions, spread of harmful non-native species, and pesticide contamination (Merelender 2000, K. Weiss pers. comm. 2018).

Livestock Grazing

Livestock grazing can be an effective habitat management tool, including control of riparian vegetation encroachment, but overgrazing can significantly degrade the environment (Siekert et al. 1985). Cattle display a strong preference for riparian areas and have been implicated as a major source of habitat damage in the western U.S. where the adverse impacts of overgrazing on riparian vegetation are intensified by arid and semi-arid climates (Behnke and Raleigh 1978, Kauffman and Krueger 1984, Belsky et al. 1999). The severity of grazing impacts on riparian systems can be influenced by the number of animals, duration and time of year, substrate composition, and soil moisture (Benhke and Raleigh 1978, Kauffman et al. 1983, Marlow and Pogacnik 1985, Siekert et al. 1985). In addition to habitat damage, cattle can directly trample any life stage of Foothill Yellow-legged Frog.

Signs of overgrazing include impacts to the streambanks such as increased slough-offs and cave-ins that collapse undercuts used as refuge (Kauffman et al. 1983). Overgrazing reduces riparian cover, increases erosion and sedimentation, which as described above can result in silt degradation of breeding, rearing, and invertebrate food-producing areas (Cordone and Kelley 1961, Behnke and Raleigh 1978, Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). Loss of streamside and instream vegetative cover and changes to channel morphology can increase water temperatures and velocities (Behnke and Raleigh 1978). Water quality can be affected by increased turbidity and nutrient input from excrement, and seasonal water quantity can be impacted through changes to channel morphology (Belsky et al. 1999). In addition, increased nutrients and temperatures can promote blooms of harmful cyanobacteria like *Microcystis aeruginosa*, which releases a toxin when it expires that can cause liver damage to amphibians as well as other animals including humans (Bobzien and DiDonato 2007, Zhang et al. 2013).

While some recent studies indicate livestock grazing continues to damage stream and riparian ecosystems, its impact on Foothill Yellow-legged Frogs in California is unknown (Belsky et al. 1999, Hayes et al. 2016). In Oregon, the species' presence was correlated with significantly less grazing than where they were absent according to Borisenko and Hayes's 1999 report (as cited in Olson and Davis 2009). However, Fellers (2005) reported that apparently some Coast Range foothill populations occupying streams draining east into the San Joaquin Valley were doing well at the time of publication despite being heavily grazed.

Urbanization and Road Effects

Habitat conversion and fragmentation combined with modified environmental disturbance regimes can substantially jeopardize biological diversity (Tracey et al. 2018). This threat is most severe in areas like California with Mediterranean-type ecosystems that are biodiversity hot spots, fire-prone, and heavily altered by human land use (Ibid.). From 1990 to 2010, the fastest-growing land use type in the conterminous U.S. was new housing construction, which rapidly expanded the wildland-urban interface (WUI) where houses and natural vegetation meet or intermix on the landscape (Radeloff et al. 2018).

Of several variables tested, proportion of urban land use within a 5 km (3.1 mi) radius of a site was associated with Foothill Yellow-legged Frog declines (Davidson et al. 2002). Lind (2005) also found significantly less urban development nearby and upwind of sites occupied by Foothill Yellow-legged Frogs, suggesting pollutant drift may be a contributing factor. Changes in wildfires may also contribute to the species' declines; 95% of California's fires are human-caused, and wildfire issues are greatest at the WUI (Syphard et al. 2009, Radeloff et al. 2018). Population density, intermix WUI (where wildland and development intermingle as opposed to an abrupt interface), and distance to WUI explained the most variability in fire frequency (Syphard et al. 2007). In addition to wildfires, habitat loss, and fragmentation, urbanization can impact adjacent ecosystems through non-native species introduction, native predator subsidization, and disease transmission (Bar-Massada et al. 2014).

Projections show growth in California's population to 51 million people by 2060 from approximately 40 million currently (PPIC 2019). This will increase urbanization, the WUI, and habitat fragmentation. The Department of Finance projects the Inland Empire, the San Joaquin Valley, and the Sacramento metropolitan area will be the fastest-growing regions of the state over the next several decades (Ibid.). This puts the greatest pressure in areas outside of the Foothill Yellow-legged Frog's range; however, because the environmental stressors associated with urbanization can span far beyond its physical footprint, they may still adversely affect the species.

Highways are frequently recognized as barriers to dispersal that fragment habitats and populations; however, single-lane roads can pose significant risks to wildlife as well (Cook et al. 2012, Brehme et al. 2018). Foothill Yellow-legged Frogs are at risk of being killed by vehicles when roads are located near their habitat (Cook et al. 2012, Brehme et al. 2018). Fifty-six juvenile Foothill Yellow-legged Frogs were found on a road adjacent to Sulphur Creek (Mendocino County), seven of which had been struck and killed (Cook et al. 2012). When fords (naturally shallow areas) are used as vehicle crossings, they can create sedimentation and poor water quality, and in some cases, the fords are gravel or cobble bars used by Foothill Yellow-legged Frogs for breeding that could result in direct mortality (K. Blanchard pers. comm. 2018, R. Bourque pers. comm. 2018). Construction of culverts under roads to keep vehicles out of the streambed can result in varying impacts. In some cases, they can impede dispersal and create deep scoured pools that support predatory fish and frogs, but when properly constructed, they can facilitate frog movement up and down the channel with reduced road mortality (Van Wagner 1996, GANDA 2008). In areas where non-native species are not a threat, but premature drying is, pools created by culverts can provide habitat in otherwise unsuitable areas (M. Grefsrud pers. comm. 2019). An evaluation of the impact of roads on 166 native California amphibians and reptiles through direct

morality and barriers to movement concluded that Foothill Yellow-legged Frogs, at individual and population levels, were at moderate risk of road impacts in aquatic habitat but very low risk of impacts in terrestrial habitat (Brehme et al. 2018). For context, all chelonids (turtles and tortoises), 72% of snakes, 50% of anurans, 18% of lizards, and 17% of salamander species in California were ranked as having a high or very high risk of negative road impacts in the same evaluation (Ibid.).

Poorly constructed roadways near rivers and streams can result in substantial erosion and sedimentation, leading to reduced amphibian densities (Welsh and Ollivier 1998). Proximity of roads to Foothill Yellow-legged Frog habitat contributes to petrochemical runoff and poses the threat of spills (Ashton et al. 1997). A diesel spill on Hayfork Creek (Trinity County) resulted in mass mortality of Foothill Yellow-legged Frog tadpoles and partial metamorphs (Bury 1972). Roads have also been implicated in the spread of disease and may have aided in the spread of Bd in California (Adams et al. 2017b).

Frogs use auditory and visual cues to defend territories and attract mates, and some studies reveal that realistic levels of traffic noise can impede transmission and reception of these signals (Bee and Swanson 2007). Some male frogs have been observed changing the frequency of their calls to increase the distance they can be heard over traffic noise, but if females have evolved to recognize lower pitched calls as signs of superior fitness, this potential trade-off between audibility and attractiveness could have implications for reproductive success (Parris et al. 2009). In a separate study, traffic noise caused a change in male vocal sac coloration and an increase in stress hormones, which changed sexual selection processes and suppressed immunity (Troïanowski et al. 2017). Because Foothill Yellow-legged Frogs mostly call underwater and are not known to use color displays, communication cues may not be adversely affected by traffic noise, but their stress response is unknown.

Timber Harvest

Because Foothill Yellow-legged Frogs tend to remain close to the water channel (i.e., within the riparian corridor) and current timber harvest practices minimize disturbance in riparian areas for the most part, adverse effects from timber harvest are expected to be relatively low (Hayes et al. 2016, CDFW 2018b). However, some activities have a potential to negatively impact Foothill Yellow-legged Frogs or their habitat, including direct mortality and increased sedimentation during construction and decommissioning of watercourse crossings and infiltration galleries, tree felling, log hauling, and entrainment by water intakes or desiccation of eggs and tadpoles through stranding from dewatering during drafting operations (CDFW 2018b,c). In addition to impacts previously described under the Sedimentation and Road Effects section, when silt runoff into streams is accompanied by organic materials, such as logging debris, impaired water quality can result, including reduced dissolved oxygen, which is important in embryonic and tadpole development (Cordone and Kelley 1961).

Because Foothill Yellow-legged Frogs are heliotherms (i.e, they bask in the sun to raise their body temperature) and sensitive to thermal extremes, some moderate timber harvest may benefit the species (Zweifel 1955, Fellers 2005). Ashton (2002) reported 85% of his Foothill Yellow-legged Frog observations occurred in second-growth forests (37-60 years post-harvest) as opposed to late-seral forests and postulated that the availability of some open canopy areas played a major part in this

disparity. Foothill Yellow-legged Frogs are typically absent in areas with closed canopy (Welsh and Hodgson 2011). Reduced canopy also raises stream temperatures, which could improve tadpole development and promote algal and invertebrate productivity in otherwise cold streams (Olson and Davis 2009; Catenazzi and Kupferberg 2013,2017).

Recreation

Several types of recreation can adversely impact Foothill Yellow-legged Frogs, and some are more severe and widespread than others. One of the main potential factors identified by herpetologists as contributing to disappearance of Foothill Yellow-legged Frogs in southern California was increased and intensified recreation in streams (Adams et al. 2017b). The greater number of people traveling into the backcountry may have facilitated the spread Bd to these areas, and while no evidence shows stress from disturbance or other environmental pressures increases susceptibility to Bd, the stress hormone corticosterone has been implicated in immunosuppression (Hayes et al. 2003, Adams et al. 2017b).

The amount of Foothill Yellow-legged Frog habitat disturbed by off-highway motor vehicles (OHV) throughout its range in California is unknown, but its impacts can be significant, particularly in areas with small isolated populations (Kupferberg et al. 2009c, Kupferberg and Furey 2015). An example is the Carnegie State Vehicular Recreation Area (CVSRA), located in the hills southwest of Tracy in the Corral Hollow Creek watershed (Alameda and San Joaquin counties). The above-described road effects apply: sedimentation, crushing along trail crossings, and potential noise effects (Ibid.). In addition, dust suppression activities employed by CSVRA use magnesium chloride ($MgCl_2$), which has the potential to harm developing embryos and tadpoles (Karraker et al. 2008, Hopkins et al. 2013, OHMVRC 2017). Based on museum records, Foothill Yellow-legged Frogs were apparently abundant in Corral Hollow Creek, but they are extremely rare now and are already extirpated or at risk of extirpation (Kupferberg et al. 2009c, Kupferberg and Furey 2015).

Motorized and non-motorized recreational boating can also impact Foothill Yellow-legged Frogs. The impacts of jet boat traffic were investigated in Oregon; in areas with frequent use and high wakes breaking on shore, Foothill Yellow-legged Frogs were absent (Borisenko and Hayes 1999 as cited in Olson and Davis 2009). This wake action had the potential to dislodge egg masses, strand tadpoles, disrupt adult basking behavior, and erode shorelines (Ibid.). Jet boat tours and races on the Klamath River (Del Norte and Humboldt counties) may have an impact on Foothill Yellow-legged Frog use of the mainstem (M. van Hattem pers. comm. 2019). In addition, using gravel bars as launch and haul out sites for boat trailers, kayaks, or river rafts can result in direct loss of egg masses and tadpoles or damage to breeding and rearing habitat and can disrupt post-metamorphic frog behavior (Ibid.). As described above, pulse flows released for whitewater boating in the late spring and summer can result in scouring and stranding of egg masses and tadpoles (Borisenko and Hayes 1999 as cited in Olson and Davis 2009, Kupferberg et al. 2009b). In addition, the velocities that resulted in stunted growth and increased vulnerability to predation in Foothill Yellow-legged Frog tadpoles were less than the increased velocities experienced in nearshore habitats during intentional release of recreational flows for whitewater boating, as well as hydropeaking for power generation (Kupferberg et al. 2011b).

Hiking, horse-riding, camping, fishing, and swimming, particularly in sensitive breeding and rearing habitat can also adversely impact Foothill Yellow-legged Frog populations (Borisenko and Hayes 1999 in Olson and Davis 2009). Because Foothill Yellow-legged Frog breeding activity was being disturbed and egg masses were being trampled by people and dogs using Carson Falls (Marin County), the land manager established an educational program, including employing docents on weekends that remind people to stay on trails and tread lightly to try to reduce the loss of Foothill Yellow-legged Frog reproductive effort (Prado 2005). In addition, within his study site, Van Wagner (1996) reported that a property owner moved rocks that were being used as breeding habitat to create a swimming hole. The extent to which this is more than a small, local problem is unknown, but as the population of California increases, recreational pressures in Foothill Yellow-legged Frog habitat are likely to increase commensurately.

Drought

Drought is a common phenomenon in California and is characterized by lower than average precipitation. Lower precipitation in general results in less surface water, and water availability is critical for obligate stream-breeding species. Even in the absence of drought, a positive relationship exists between precipitation and latitude within the Foothill Yellow-legged Frog's range in California, and mean annual precipitation has a strong influence on Foothill Yellow-legged Frog presence at historically occupied sites (Davidson et al. 2002, Lind 2005). Figure 22 depicts the recent historical annual average precipitation across the state as well as during the most recent drought and how they differ. Southern California is normally drier than northern California, but the severity of the drought was even greater in the south.

Reduced precipitation can result in deleterious effects to Foothill Yellow-legged Frogs beyond the obvious premature drying of aquatic habitat. When stream flows recede during the summer and fall, sometimes the isolated pools that stay perennially wet are the only remaining habitat. This phenomenon concentrates aquatic species, resulting in several potentially significant adverse impacts. Stream flow volume was negatively correlated with Bd load during a recent chytridiomycosis outbreak in the Alameda Creek watershed (Adams et al. 2017a). The absence of high peak flows in winter coupled with wet years allowed bullfrogs to expand their distribution upstream, and the drought-induced low flows in the fall concentrated them with Foothill Yellow-legged Frogs in the remaining drying pools (Ibid.). This mass mortality event appeared to have been the result of a combination of drought, disease, and dam effects (Ibid.). This die-off occurred in a regulated reach that experiences heavy recreational use and presence of crayfish and bass (Ibid.). Despite these threats, the density of breeding females in this reach was greater in 2014 and 2015 than ~~the~~ in the unregulated reach upstream because the latter dried completely before tadpoles could metamorphose during the preceding drought years (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015).

In addition to increasing the spread of pathogens, drought-induced stream drying can increase predation and competition by introduced fish and frogs in the pools they are forced to share (Moyle 1973, Hayes and Jennings 1988, Drost and Fellers 1996). This concentration in isolated pools can also result in increased native predation as well as facilitate spread of Bd. An aggregation of six adult Foothill

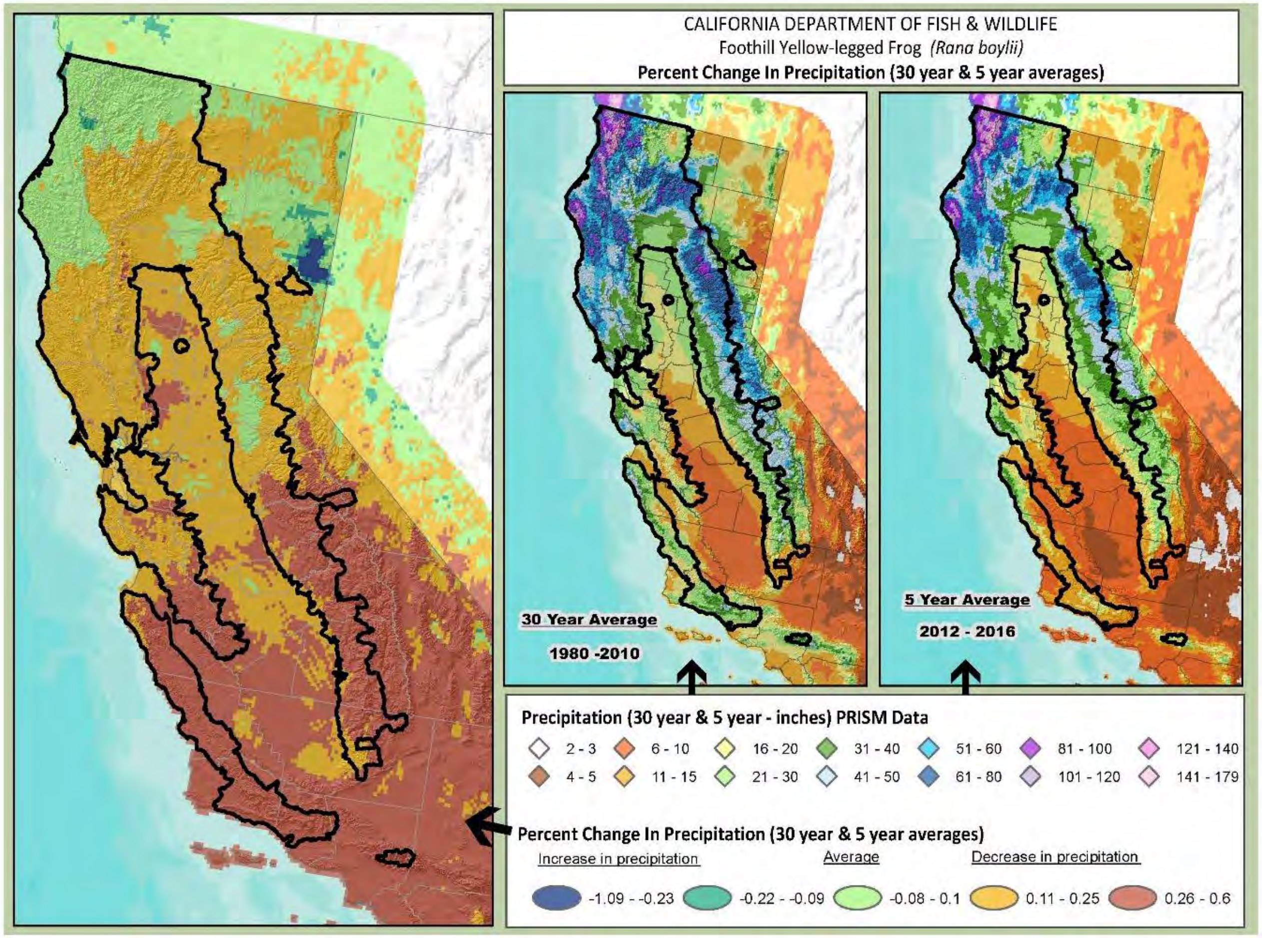


Figure 22. Change in precipitation from 30-year average and during the recent drought (PRISM)

Yellow-legged Frogs was observed perched on a rock above an isolated pool where a gartersnake was foraging on tadpoles during the summer; this close contact may reduce evaporative water loss when they are forced out of the water during high temperatures, but it can also increase disease transmission risk (Leidy et al. 2009.). Gonsolin (2010) also documented a late summer aggregation of juvenile Foothill Yellow-legged Frogs out of water during extremely high temperatures. In addition, drought-induced low flow, high water temperatures, and high densities of tadpoles were associated with outbreaks of malformation-inducing parasitic copepods (Kupferberg et al. 2009a).

Rapidly receding spring flows can result in stranding egg masses and tadpoles. However, this risk is likely less significant when it is drought-induced on an unregulated stream vs. a result of dam operations since Foothill Yellow-legged Frogs have evolved to initiate breeding earlier and shorten the breeding period in drought years (Kupferberg 1996a). If pools stay wet long enough to support metamorphosis, complete drying at the end of the season may benefit Foothill Yellow-legged Frogs if it eliminates introduced species like warm water fish and bullfrogs. Moyle (1973) noted that the only intermittent streams occupied by Foothill Yellow-legged Frogs in the Sierra Nevada foothills had no bullfrogs. At a long-term study site in upper Coyote Creek in 2015, Foothill Yellow-legged Frogs had persisted in reaches that had at least some summer water through the three preceding years of the most severe drought in over a millennium, albeit at much lower abundance than a decade before (Gonsolin 2010, Griffin and Anchokaitis 2014, J. Smith pers. comm. 2015). The population's abundance appeared to have never recovered from the 2007-2009 drought before the 2012-2016 drought began (J. Smith pers. comm. 2015). In 2016, after a relatively wet winter, Foothill Yellow-legged Frogs bred en masse, and only a single adult bullfrog was detected, an unusually low number for that area (CDWR 2016, J. Smith pers. comm. 2016). It appeared the population may rebound; however, in 2018, it experienced lethal chytridiomycosis outbreak, and like the Alameda Creek die-off probably resulted from crowding during drought, presence of bullfrogs as Bd-reservoirs and predators and competitors, and the stress associated with the combination of the two (Kupferberg and Catenazzi 2019).

Drought effects can also exacerbate the effects of other environmental stressors. During the most recent severe drought, tree mortality increased dramatically from 2014 to 2017 and reached approximately 129 million dead trees (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are more prone to severe wildfires, and they lose their carbon sequestration function while also emitting methane, which is an extremely damaging greenhouse gas (CNRA 2016). Post-wildfire storms can result in erosion of fine sediments from denuded hillsides into the stream channel (Florsheim et al. 2017). If the storms are short duration and ~~low precipitation~~peak discharges are low in magnitude, as happens during droughts, ~~their magnitude may not~~streamflow may be insufficient to transport the material downstream, ~~resulting in a longer temporal loss or~~extending the duration of ~~degradation of~~ stream habitat degradation (Ibid.). Reduced rainfall may also infiltrate the debris leading to subsurface flows rather than the surface water Foothill Yellow-legged Frogs require (Ibid.). Extended droughts increase risk of the stream being uninhabitable or inadequate for breeding for multiple years, which would result in population-level impacts and possible extirpation (Ibid.).

Wildland Fire and Fire Management

Fire is an important element for shaping and maintaining the species composition and integrity of many California ecosystems (Syphard et al. 2007, SBFFP 2018). Prior to European settlement, an estimated 1.8 to 4.9 million ha (4.5-12 million ac) burned annually (4-11% of total area of the state), ignited both deliberately by Native Americans and through lightning strikes (Keeley 2005, SBFFP 2018). The impacts of wildland fires on Foothill Yellow-legged Frogs are poorly understood and likely vary significantly across the species' range with differences in climate, vegetation, soils, stream-order, slope, frequency, and severity (Olson and Davis 2009). Mortality from direct scorching is unlikely because Foothill Yellow-legged Frogs are highly aquatic, and most wildfires occur during the dry period of the year when the frogs are most likely to be in or near the water (Pilliod et al. 2003, Bourque 2008). Field observations support this presumption; sightings of post-metamorphic Foothill Yellow-legged Frogs immediately after fires in the northern Sierra Nevada and North Coast indicate they are not very vulnerable to the direct effects of fire (S. Kupferberg and R. Peek pers. comm. 2018). Similarly, Foothill Yellow-legged Frogs were observed two months, and again one year, after a low- to moderate-intensity fire burned an area in the southern Sierra Nevada in 2002, and the populations were extant and breeding as recently as 2017 (Lind et al. 2003b, CNDDB 2019). While water may provide a refuge during the fire, it is also possible for temperatures during a fire, or afterward due to increased solar exposure, to near or exceed a threshold resulting lethal or sublethal harm; this would likely impact embryos and tadpoles with limited dispersal abilities (Pilliod et al. 2003).

Intense fires remove overstory canopy, which provides insulation from extreme heat and cold, and woody debris that increases habitat heterogeneity (Pilliod et al. 2003, Olson and Davis 2009). If this happens frequently enough, it can permanently change the landscape. For example, frequent high-severity burning of crown fire-adapted ecosystems can prevent forest regeneration since seeds require sufficient time between fires to mature, and repeated fires can deplete the seed bank (Stephens et al. 2014). Smoke and ash change water chemistry through increased nutrient and heavy metal inputs that can reach concentrations harmful to aquatic species during the fire and for days, weeks, or years after (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Erosion rates on granitic soils, which make up a large portion of the Foothill Yellow-legged Frog's range, can be over 60 times greater in burned vs. unburned areas and can increase sedimentation for over 10 years (Megahan et al. 1995, Hayes et al. 2016). Post-fire nutrient inputs into streams could benefit Foothill Yellow-legged Frogs through increased productivity and more rapid growth and development (Pilliod et al. 2003). While the loss of leaf litter that accompanies fire alters the food web, insects are expected to recolonize rapidly, and the lack of cover could increase their vulnerability to predation by Foothill Yellow-legged Frogs (Ibid.).

Low-intensity fires likely have no adverse effect on Foothill Yellow-legged Frogs (Olson and Davis 2009). If they occur in areas with dense canopy, wildfires can improve habitat quality for Foothill Yellow-legged Frogs by reducing riparian cover, providing areas to bask, and increasing habitat heterogeneity, which is likely to outweigh any adverse effects from some fire-induced mortality (Russell et al. 1999, Olson and Davis 2009). In a preliminary analysis of threats to Foothill Yellow-legged Frogs in Oregon, proximity to stand-replacing fires was not associated with absence (Olson and Davis 2009).

Euro-American colonization of California significantly altered the pattern of periodic fires with which California's native flora and fauna evolved through fire exclusion, land use practices, and development (OEHHA 2018). Fire suppression can lead to canopy closure, which reduces habitat quality by limiting thermoregulatory opportunities (Olson and Davis 2009). In addition, fire suppression and its subsequent increase in fuel loads combined with expanding urbanization and rising temperatures have resulted in a greater likelihood of catastrophic stand-replacing fires that can significantly alter riparian systems for decades (Pilliod et al. 2003). Firebreaks, in which vegetation is cleared from a swath of land, can result in similar impacts to roads and road construction (Ibid.). Fire suppression can also include bulldozing within streams to create temporary reservoirs for pumping water, which can cause more damage than the fire itself to Foothill Yellow-legged Frogs in some cases (S. Kupferberg and R. Peek pers. comm. 2018). In addition, fire suppression practices can involve applying hundreds of tons of ammonia-based fire retardants and surfactant-based fire suppressant foams from air tankers and fire engines (Pilliod et al. 2003). Some of these chemicals are highly toxic to some anurans (Little and Calfee 2000).

Fire suppression has evolved into fire management with a greater understanding of its importance in ecosystem health (Keeley and Syphard 2016). Several strategies are employed including prescribed burns, mechanical fuels reduction, and allowing some fires to burn instead of necessarily extinguishing them (Pilliod et al. 2003). Like wildfires themselves, fire management strategies have the potential to benefit or harm Foothill Yellow-legged Frogs. Prescribed fires and mechanical fuels removal lessen the likelihood of catastrophic wildfires, but they can also result in loss of riparian vegetation, excessive sedimentation, and increased water temperatures (Ibid.). Salvage logging after a fire may result in similar impacts to timber harvest but with higher rates of erosion and sedimentation (Ibid.). A balanced approach to wildland fires is likely to have the greatest beneficial impact on species and ecosystem health (Stephens et al. 2012).

Floods and Landslides

As previously described, Foothill Yellow-legged Frog persistence is highly sensitive to early life stage mortality (Kupferberg et al. 2009c). While aseasonal dam releases are a major source of egg mass and tadpole scouring, storm-driven floods are also capable of it (Ashton et al. 1997). Van Wagner (1996) concluded that the high discharge associated with heavy rainfall could account for a significant source of mortality in post-metamorphic Foothill Yellow-legged Frogs as well as eggs and tadpoles; he observed two adult females and several juveniles swept downstream with fatal injuries post-flooding. Severe flooding, specifically two 500-year flood events in early 1969 in Evey Canyon (Los Angeles County), resulted in massive riparian habitat destruction (Sweet 1983). Prior to the floods, Foothill Yellow-legged Frogs were widespread and common, but only four subsequent sightings were documented between 1970 and 1974 and none since (Sweet 1983, Adams 2017b). Sweet (1983) speculates that because Foothill Yellow-legged Frogs overwinter in the streambed in that area, the floods may have reduced the population's abundance below an extinction threshold. Four other herpetologists interviewed about Foothill Yellow-legged Frog extirpations in southern California listed severe flooding as a likely cause (Adams et al. 2017b).

As mentioned above, landslides are a frequent consequence of post-fire rainstorms and can result in lasting impacts to stream morphology, water quality, and Foothill Yellow-legged Frog populations. On the other hand, Olson and Davis (2009) suggest that periodic landslides can have beneficial effects by transporting woody debris into the stream that can increase habitat complexity and by replacing sediments that are typically washed downstream over time. Whether a landslide is detrimental or beneficial is likely heavily influenced by amount of precipitation and the underlying system. As previously described, too little precipitation could lead to prolonged loss of habitat through failure to transport material downstream, and too much precipitation can result in large-scale habitat destruction and direct mortality.

Climate Change

Global climate change threatens biodiversity and may lead to increased frequency and severity of drought, wildfires, flooding, and landslides (Williams et al. 2008, Keely and Syphard 2016). Data show a consistent trend of warming temperatures in California and globally; 2014 was the warmest year on record, followed by 2015, 2017, and 2016 (OEHHA 2018). Climate model projections for annual temperature in California in the 21st century range from 1.5 to 4.5°C (2.7-8.1°F) greater than the 1961-1990 mean (Cayan et al. 2008). Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation, and increasingly dry conditions in California resulting from increased evaporative water loss primarily due to rising temperatures (Cayan et al. 2005, Williams et al. 2015, OEHHA 2018). Precipitation variability and proportion of dry years were negatively associated with Foothill Yellow-legged Frog presence in a range-wide analysis (Lind 2005). In addition, low precipitation intensified the adverse effects of dams on the species (Ibid.).

California recently experienced the longest drought since the U.S. Drought Monitor began reporting in 2000 (NIDIS 2019). Until March 5, 2019, California experienced drought effects in at least a portion of the state for 376 consecutive weeks; the most intense period occurred during the week of October 28, 2014 when D4 (the most severe drought category) affected 58.4% of California's land area (Figure 23; NIDIS 2019). A recent modeling effort using data on historical droughts, including the Medieval megadrought between 1100 and 1300 CE, indicates the mean state of drought from 2050 to 2099 in California will likely exceed the Medieval-era drought, under both high and moderate greenhouse gas emissions models (Cook et al. 2015). The probability of a multidecadal (35 yr) drought occurring during the late 21st century is greater than 80% in all models used by Cook et al. (2015). If correct, this would represent a climatic shift that not only falls outside of contemporary variability in aridity but would also be unprecedented in the past millennium (Ibid.).

As a result of increasing temperatures, a decreasing proportion of precipitation falls as snow, resulting in more runoff from rainfall during the winter and a shallower snowpack that melts more rapidly (Stewart 2009). A combination of reduced seasonal snow accumulation and earlier streamflow timing significantly reduces surface water storage capacity and increases the risk for winter and spring floods, which may require additional and taller dams and result in alterations to hydroelectric power generation flow regimes (Cayan et al. 2005, Knowles et al. 2006, Stewart 2009). The reduction in snowmelt volume

is expected to impact the northern Sierra (Feather, Yuba, and American River watersheds) to a greater extent than the southern portion (Young et al. 2009). The earlier shift in peak snowmelt timing is predicted to exceed four to six weeks across the entire Sierra Nevada depending on the amount of warming that occurs this century (Ibid.). In addition, the snow water equivalent is predicted to significantly decline by 2070-2099 over the 1961-1990 average in the Trinity, Sacramento, and San Joaquin drainages from -32% to -79%, and effectively no snow is expected to fall below 1000 m (3280 ft) in the high emissions/sensitive model (Cayan et al. 2008).

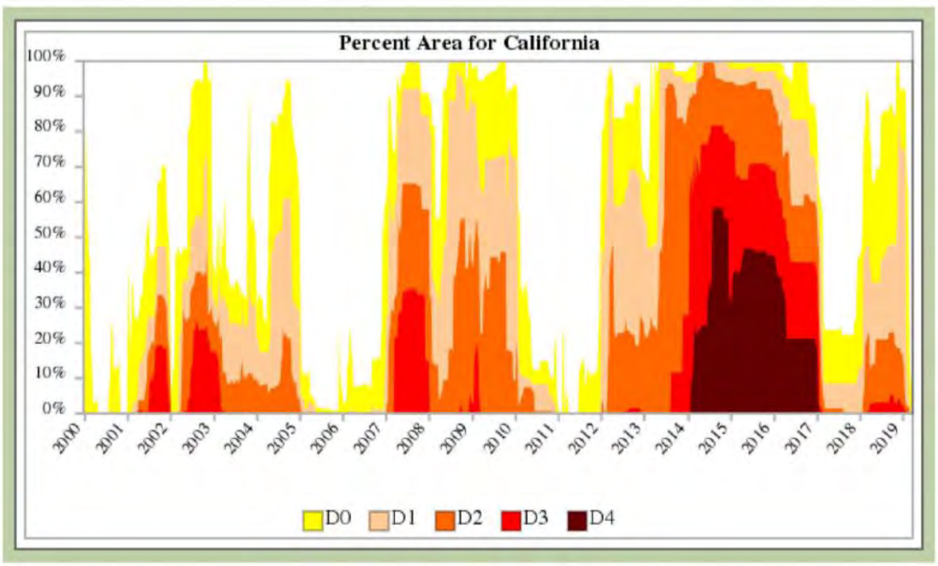


Figure 23. Palmer Hydrological Drought Indices 2000-present (NIDIS)

The earlier shift of snowmelt and lower water content will result in lower summer flows, which will intensify the competition for water among residential, agricultural, industrial, and environmental needs (Field et al. 1999, Cook et al. 2015). In unregulated systems, as long as water is present through late summer, an earlier hydrograph recession that triggers Foothill Yellow-legged Frog breeding could result in a longer time to grow larger prior to metamorphosis, which improves probability of survival (Yarnell et al. 2010, Kupferberg 2011b). However, if duration from peak to base flow shortens, it can result in increased sedimentation and reduced habitat complexity in addition to stranding (Yarnell et al. 2010).

Fire frequency relates to temperature, fuel loads, and fuel moisture (CCSP 2008). Therefore, increasing periods of drought combined with extreme heat and low humidity that stress or kill trees and other vegetation create ideal conditions for wildland fires (Ibid). Not surprisingly, the area burned by wildland fires over the western U.S. increased since 1950 but rose rapidly in the mid-1980s (Westerling et al. 2006, OEHHA 2018). As temperatures warmed and snow melted earlier, large-wildfire frequency and duration increased, and wildfire seasons lengthened (Westerling et al. 2006, OEHHA 2018).

In California, latitude inversely correlates with temperature and annual area burned, but the climate-fire relationship is substantially different across the state, and future wildfire regimes are difficult to predict (Keeley and Syphard 2016). For example, the relationship between spring and summer temperature and area burned in the Sierra Nevada is highly significant but not in southern California (Ibid.). Climate has a greater influence on fire regimes in mesic than arid environments, and the most influential climatological factor (e.g., precipitation, temperature, season, or their interactions) shifts over time (Ibid.). Nine of the 10 largest fires in California since 1932 have occurred in the past 20 years, 4 within the past 2 years (Figure 24; CAL FIRE 2019). However, it is possible this trend will not continue; climate- and wildfire-induced changes in vegetation could reduce wildfire severity in the future (Parks et al. 2016).

Wildfires themselves can accelerate the effects of climate change. Wildfires emit short-lived climate pollutants like black carbon (soot) and methane that are tens to thousands of times greater than carbon dioxide (the main focus of greenhouse gas reduction) in terms of warming effect and are responsible for 40% or more of global warming to date (CNRA 2016). Healthy forests can sequester large amounts of carbon from the atmosphere, but recently carbon emissions from wildfires have exceeded their uptake by vegetation in California (Ackerly et al. 2018).

With increased variability and changes in precipitation type, magnitude, and timing comes more variable and extreme stream flows (Mallakpour et al. 2018). Models for stream flow in California project higher high flows, lower low flows, wetter rainy seasons, and drier dry seasons (Ibid.). The projected water cycle extremes are related to strengthening El Niño and La Niña events, and both severe flooding and intense drought are predicted to increase by at least 50% by the end of the century (Yoon et al. 2015). These changes increase the likelihood of Foothill Yellow-legged Frog egg mass and tadpole scouring and stranding, even in unregulated rivers.

A species' vulnerability to climate change is a function of its sensitivity to climate change effects, its exposure to them, and its ability to adapt its behaviors to survive with them (Dawson et al. 2011). Myriad examples exist of species shifting their geographical distribution toward the poles and to higher elevations and changing their growth and reproduction with increases in temperature over time (Parmesan and Yohe 2003). However, in many places, fragmentation of suitable habitat by anthropogenic barriers (e.g., urbanization, agriculture, and reservoirs) limits a species' ability to shift its range (Pounds et al. 2007). The proportion of sites historically occupied by Foothill Yellow-legged Frogs that are now extirpated increases significantly on a north-to-south latitudinal gradient and at drier sites within California, suggesting climate change may contribute to the spatial pattern of the species' declines (Davidson et al. 2002).

An analysis of the climate change sensitivity of 195 species of plants and animals in northwestern North America revealed that, as a group, amphibians and reptiles were estimated to be the most sensitive (Case et al. 2015). Nevertheless, examples exist of amphibians adjusting their breeding behaviors (e.g., calling and migrating to breeding sites) to occur earlier in the year as global warming increases (Beebee 1995, Gibbs and Breisch 2001). Because of the rapid change in temperature, Beebee (1995) posits these are examples of behavioral and physiological plasticity rather than natural selection. However, for

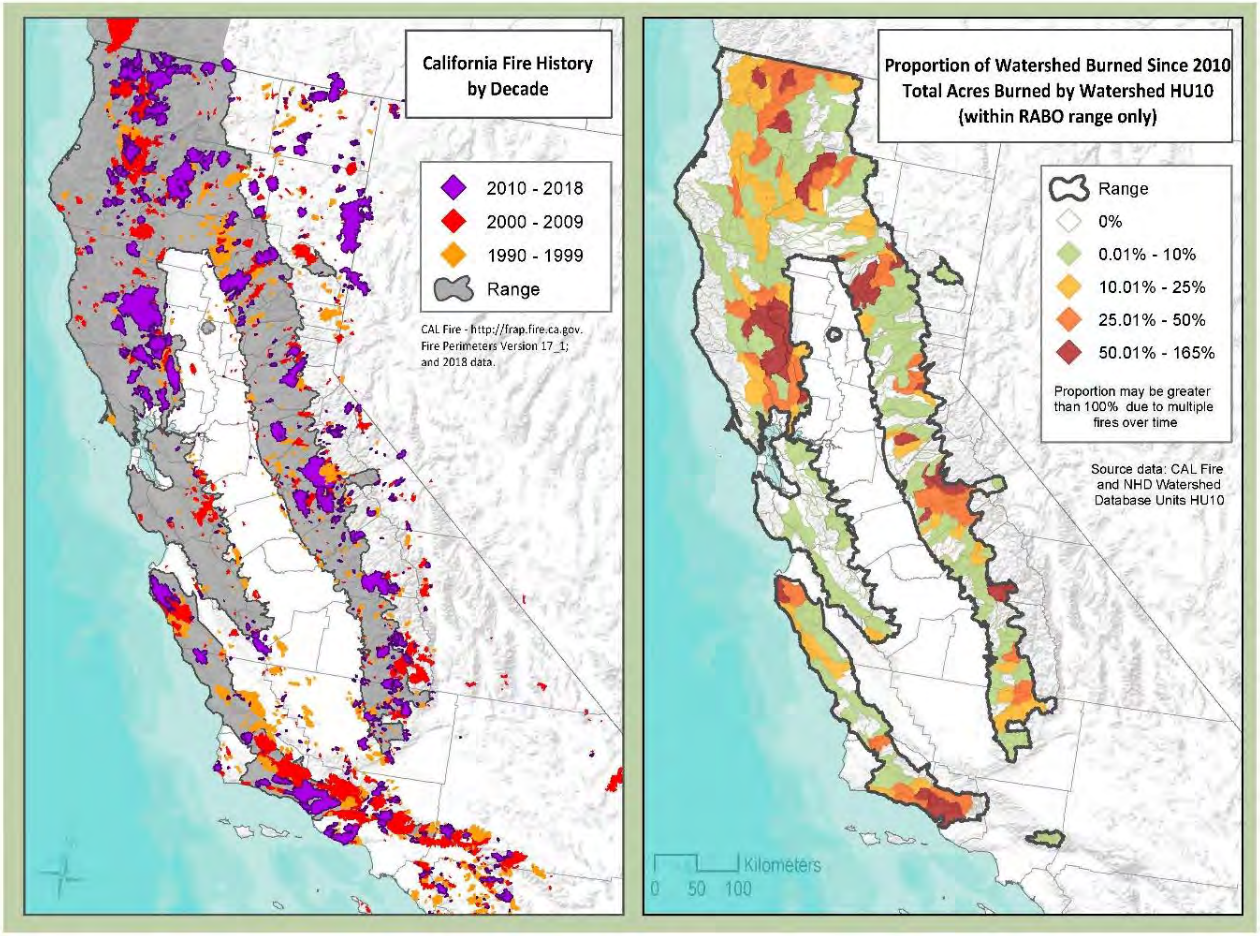


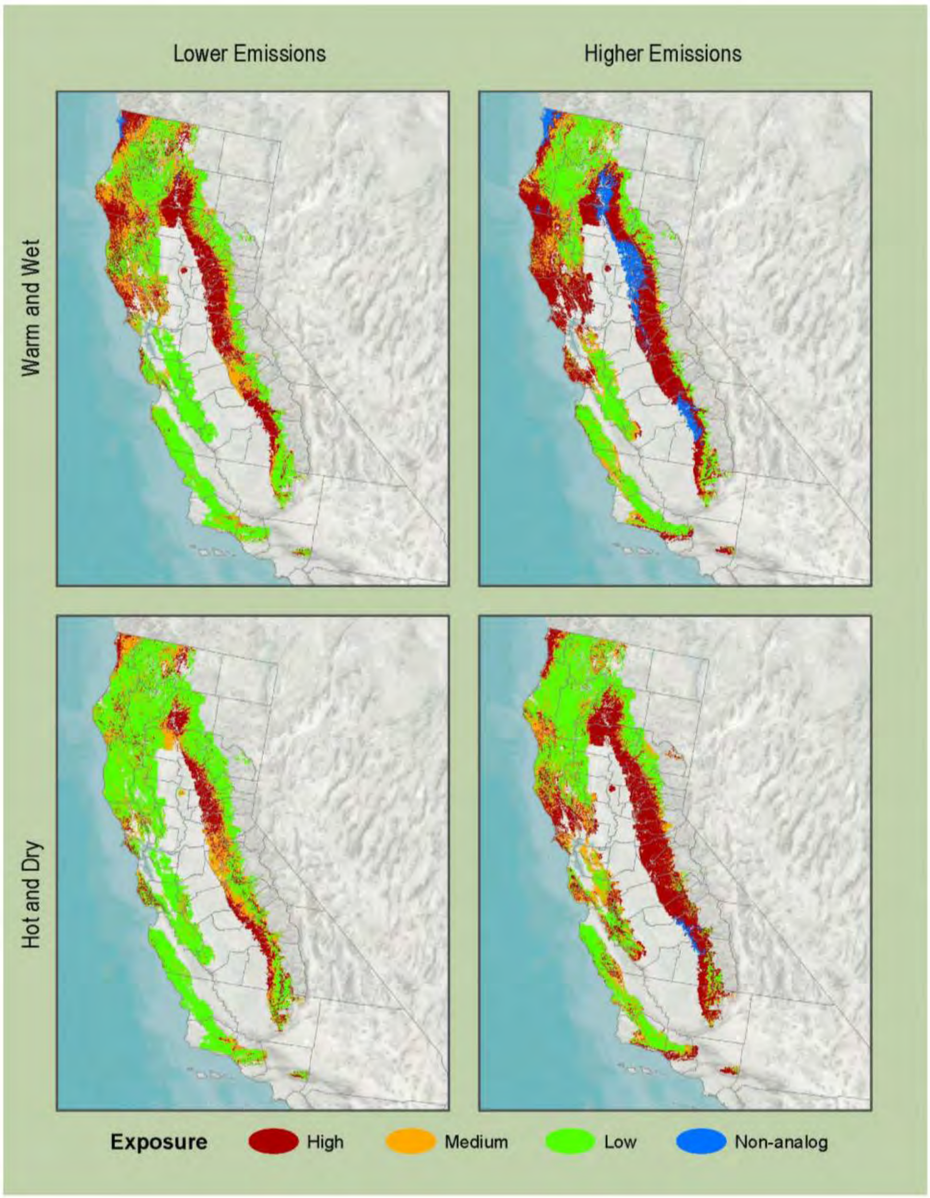
Figure 24. Fire history (1990-2018) and proportion of watershed burned (2010-2018) in California (CAL FIRE, NHD)

species with short generation times or in areas less affected by climate change, populations may be able to undergo evolutionary adaptation to the changing local environmental conditions (Hoffman and Sgrò 2011).

As previously described in the Seasonal Activity and Movements section, Foothill Yellow-legged Frog breeding is closely tied to water temperature, flow, and stage, and the species already adjusts its timing of oviposition by as much as a month in the same location during different water years, so the species may have enough inherent flexibility to reduce their vulnerability. The species appears fairly resilient to drought, fire, and flooding, at least in some circumstances. For example, after the 2012-2016 drought, the Loma Fire in late 2016, and severe winter flooding and landslides in 2016 and 2017, Foothill Yellow-legged Frog adults and metamorphs, as well as aquatic insects and rainbow trout, were abundant throughout Upper Llagas Creek in fall of 2017, and the substrate consisted of generally clean gravels and cobbles with only a slight silt coating in some pools (J. Smith pers. comm. 2017). The frogs and fish likely took refuge in a spring-fed pool, and the heavy rains scoured the fine sediments that eroded downstream (Ibid.). These refugia from the effects of climate change reduce the species' exposure, thereby reducing their vulnerability (Case et al. 2015).

Climate change models that evaluate the Foothill Yellow-legged Frog's susceptibility from a species and habitat perspective yield mixed results. An investigation into the possible effects of climate on California's native amphibians and reptiles used ecological niche models, future climate scenarios, and general circulation models to predict species-specific climatic suitability in 2050 (Wright et al. 2013). The results suggested approximately 90-100% of localities currently occupied by Foothill Yellow-legged Frogs are expected to remain climatically suitable in that time, and the proportion of currently suitable localities predicted to change ranges from -20% to 20% (Ibid.). However, a second study using a subset of these models found that 66.4% of currently occupied cells will experience reduced environmental suitability in 2050 (Warren et al. 2014). This analysis included 90 species of native California mammals, birds, reptiles, and amphibians. For context, over half of the taxa were predicted to experience > 80% reductions, a consistent pattern reflected across taxonomic groups (Ibid.).

A third analysis investigated the long-term risk of climate change by modeling the relative environmental stress a vegetative community would undergo in 2099 given different climate and greenhouse gas emission scenarios (Thorne et al. 2016). This model does not incorporate any Foothill Yellow-legged Frog-specific data; it strictly projects climatic stress levels vegetative communities will experience within the species' range boundaries (Ibid.). Unsurprisingly, higher emissions scenarios resulted in a greater proportion of habitat undergoing climatic stress (Figure 25). Perhaps counterintuitively, the warm and wet scenario resulted in a greater amount of stress than the hot and dry scenario. When high emissions and warm and wet changes are combined, a much greater proportion of the vegetation communities will experience "non-analog" conditions, those outside of the range of conditions currently known in California (Ibid.).



Source - model extracts from -Thorne, J.H. et al. (2016) A climate change vulnerability assessment of California's terrestrial vegetation. CDFW.

Figure 25. Vegetative community exposure to climate change in 2099 based on Thorne et al. (2016).

Habitat Restoration and Species Surveys

Potential conflicts between managing riverine habitat below dams for both cold-water adapted salmonids and Foothill Yellow-legged Frogs was discussed previously. In addition to problems with temperatures and pulse flows, some stream restoration projects aimed at physically creating or improving salmonid habitat can also adversely affect the species. For example, boulder deflectors were placed in Hurdygurdy Creek (Del Norte County) to create juvenile steelhead rearing habitat; deflectors change broad, shallow, low-velocity reaches into narrower, deeper, faster reaches preferred by the fish (Fuller and Lind 1992). Foothill Yellow-legged Frogs were documented using the restoration reach as breeding habitat annually prior to placement of the boulders, but no breeding was detected in the following three years, suggesting this project eliminated the conditions the frogs require (Ibid.). In addition, a fish ~~ladder~~ passage structure to facilitate salmonid migration above the Alameda Creek Diversion Dam was recently constructed on a Foothill Yellow-legged Frog lek site~~,~~; the structure blocks a migratory pathway between overwintering habitat in springs and seeps on a hillside and the creek; and creates a potential trap ~~the~~ for frogs ~~may become trapped~~that fall ~~in~~into the ~~ladder~~ structure (M. Grefsrud pers. comm. 2019). Use of rotenone to eradicate non-native fish as part of a habitat restoration project is rare, but if it is applied in streams occupied by Foothill Yellow-legged Frogs, it can kill tadpoles but is unlikely to impact post-metamorphic frogs (Fontenot et al. 1994). Metamorphosing tadpoles may be able to stay close enough to the surface to breathe air and survive but may display lethargy and experience increased susceptibility to predation (Ibid.).

Commented [SK2]: I think ladder is a misnomer for this massive concrete structure – I think it has 37 rectangular pools, it's huge

Commonly when riparian vegetation is removed, regulatory agencies require a greater amount to be planted as mitigation to offset the temporal loss of habitat. This practice can have adverse impacts on habitat suitability Foothill Yellow-legged Frogs, especially where flood suppression by dams has resulted in the active channel being encroached by riparian trees whose roots bind sediment and steepen the slope of the banks. ~~by reducing habitat suitability~~. Foothill Yellow-legged Frogs have been observed moving into areas where trees were recently removed, and they are known to avoid heavily shaded areas (Lind et al. 1996, Welsh and Hodgson 2011, M. Grefsrud pers. comm. 2019).

Biologists and other stream researchers can inadvertently harm Foothill Yellow-legged Frogs. When ~~conducting surveys~~working in Foothill Yellow-legged Frog habitat, in-stream surveyors can trample egg masses or larvae if they are not careful, and those rock-hopping on shore can unknowingly crush post-metamorphic life stages that often take cover under stream-side rocks. One method for sampling fish is electroshocking, which runs a current through the water that stuns the fish temporarily allowing them to be captured. Post-metamorphic frogs are unlikely to be killed by electroshocking; however, at high frequencies (60 Hz), they may experience some difficulty with muscle coordination for a few days (Allen and Riley 2012). This could increase their risk of predation. At 30 Hz, there were no differences between frogs that were shocked and controls (Ibid.). Tadpoles are more similar to fish in tail muscle and spinal structure and are at higher risk of injuries; however, researchers who reported observing stunned tadpoles noted they appeared to recover completely within several seconds (Ibid.). Adverse effects to Foothill Yellow-legged Frogs from electrofishing may only happen at frequencies higher than those typically used for fish sampling (Ibid.)

Small Population Sizes

Small populations are at greater risk of extirpation, primarily throughbecause the effects of demographic, environmental, and genetic stochasticity are disproportionately greater impact of demographic, environmental, and genetic stochasticity on them compared tothan effects on large populations, . so Thus, any of the threats previously discussed will likely have an even greater adverse impact on small populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). This risk of extinction from genetic stochasticity is amplified when connectivity between the small populations, and thus gene flow, is impeded (Fahrig and Merriam 1985, Taylor et al. 1993, Lande and Shannon 1996, Palstra and Ruzzante 2008). Genetic diversity provides capacity to evolve in response to environmental changes, and the "rescue effect" of gene flow is important in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). However, the rescue effect is diminished in conditions of high local environmental stochasticity of recruitment or survival (Eriksson et al. 2014). In addition, populations living near their physiological limits and lacking adaptive capacity may not be able to evolve in response to rapid changes (Hoffmann and Sgrò 2011). Furthermore, while pathogens or parasites rarely result in host extinction, they can increase its likelihood in small populations by driving the host populations below a critically low threshold beneath which demographic stochasticity can lead to extinction, even if they possess the requisite genetic diversity to adapt to a changed environment (Gomulkiewicz and Holt 1995, Adams et al. 2017b).

A Foothill Yellow-legged Frog PVA revealed that, even with no dam effects considered (e.g., slower growth and increased egg and tadpole mortality), populations with the starting average density of adult females in regulated rivers (4.6/km [2.9/mi]) were four times more likely to go extinct within 30 years than those with the starting average density of adult females from unregulated rivers (32/km [120/mi]) (Kupferberg et al. 2009c). When the density of females in sparse populations was used (2.1/km [1.3/mi], the 30-year risk of extinction increased 13-fold (Ibid.). With dam effects, a number of the risk factors above contribute to the additional probability of local extinction such as living near their lower thermal tolerance and reduced recruitment and survival from scouring and stranding flows, poor food quality, and increased predation and competition (Kupferberg 1997a; Hoffmann and Sgrò 2011; Kupferberg et al. 2011a,b; Kupferberg et al. 2012; Eriksson et al. 2014). These factors act synergistically, contributing in part to the small size, high divergence, and low genetic diversity exhibited by many Foothill Yellow-legged Frog populations located in highly regulated watersheds (Kupferberg et al. 2012, Peek 2018).

EXISTING MANAGEMENT

Land Ownership within the California Range

Using the Department's Foothill Yellow-legged Frog range boundary and the California Protected Areas Database (CPAD), a GIS dataset of lands that are owned in fee title and protected for open space purposes by over 1,000 public agencies or non-profit organizations, the total area of the species' range in California comprises 13,620,447 ha (33,656,857 ac) (CPAD 2019, CWHR 2019). Approximately 37% is owned by federal agencies, 80% of which (4,071,178 ha [10,060,100 ac]) is managed by the Forest Service (Figure 26). Department of Fish and Wildlife-managed lands, State Parks, and other State agency-managed lands constitute around 2.6% of the range. The remainder of the range includes < 1% Tribal lands, 2.3% other conserved lands (e.g., local and regional parks), and 57% private and government-managed lands that are not protected for open space purposes. It is important to note that even if included in the CPAD, a property's management does not necessarily benefit Foothill Yellow-legged Frogs, but in some cases changes in management to conserve the species may be easier to undertake than on private lands or public lands not classified as conserved.

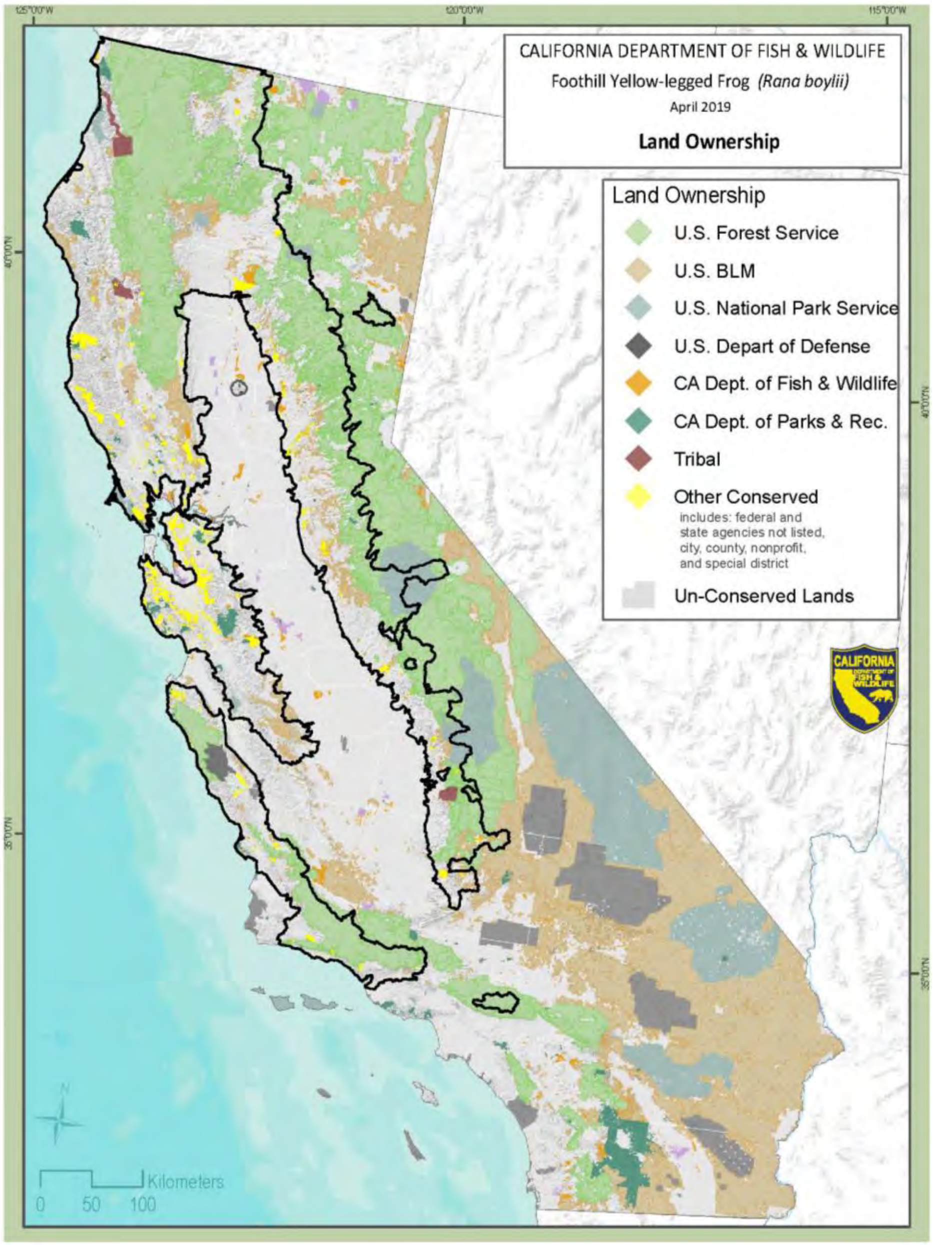


Figure 26. Conserved, Tribal, and other lands (BLM, CMD, CPAD, CWHR, DOD)

Statewide Laws

The laws and regulations governing land management within the Foothill Yellow-legged Frog's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California that may provide some level of protection for Foothill Yellow-legged Frogs and their habitat. The following is not an exhaustive list.

National Environmental Policy Act and California Environmental Quality Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. As a BLM and Forest Service Sensitive Species, impacts to Foothill Yellow-legged Legged Frogs are considered during NEPA analysis; however, the law has no requirement to minimize or mitigate adverse effects.

The California Environmental Quality Act (CEQA) is similar to NEPA; it requires state and local agencies to identify, analyze, and consider alternatives, and to publicly disclose environmental impacts from projects over which they have discretionary authority (Pub. Resources Code § 21000 et seq.). CEQA differs substantially from NEPA in requiring mitigation for significant adverse effects to a less than significant level unless overriding considerations are documented. CEQA requires an agency find projects may have a significant effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380.). CEQA establishes a duty for public agencies to avoid or minimize such significant effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to Foothill Yellow-legged Frogs, as an SSC, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA. However, a lead agency is not required to make a mandatory finding of significance conclusion unless it determines on a project-specific basis that the species meets the CEQA criteria for rare, threatened, or endangered.

Clean Water Act and Porter-Cologne Water Quality Control Act

The Clean Water Act originated in 1948 as the Federal Water Pollution Control Act of 1948. It was heavily amended in 1972 and became known as the Clean Water Act (CWA). The purpose of the CWA was to establish regulations for the discharge of pollutants into waters of the United States and establish quality standards for surface waters. Section 404 of the CWA forbids the discharge of dredged or fill material into waters and wetlands without a permit from the ACOE. The CWA also requires an alternatives analysis, and the ACOE is directed to issue their permit for the least environmentally damaging practicable alternative. The definition of waters of the United States has changed substantially over time based on Supreme Court decisions and agency rule changes.

The Porter-Cologne Water Quality Act was established by the State in 1969 and is similar to the CWA in that it establishes water quality standards and regulates discharge of pollutants into state waters, but it

also administers water rights which regulate water diversions and extractions. The SWRCB and nine Regional Water Boards share responsibility for implementation and enforcement of Porter-Cologne as well as the CWA's National Pollutant Discharge Elimination System permitting.

Federal and California Wild and Scenic Rivers Acts

In 1968, the U.S. Congress passed the federal Wild and Scenic Rivers Act (WSRA) (16 U.S.C. § 1271, et seq.) which created the National Wild and Scenic River System. The WSRA requires the federal government to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The WSRA prohibits the federal government from building, licensing, funding or otherwise aiding in the building of dams or other project works on rivers or segments of designated rivers. The WSRA does not give the federal government control of private property including development along protected rivers.

California's Wild and Scenic Rivers Act was enacted in 1972 so rivers that "possess extraordinary scenic, recreational, fishery, or wildlife values shall be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the state." (Pub. Res. Code, § 5093.50). Designated waterways are codified in Public Resources Code sections 5093.50-5093.70. In 1981, most of California's designated Wild and Scenic Rivers were adopted into the federal system. Currently in California, 3,218 km (1,999.6 mi) of 23 rivers are protected by the WSRA, most of which are located in the northwest. Foothill Yellow-legged Frogs have been observed in 11 of the 17 designated rivers within their range (CNDDB 2019).

Lake and Streambed Alteration Agreements

Fish and Game Code Section 1602 requires entities to notify the Department of activities that "divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake." If the activity may substantially adversely affect an existing fish and wildlife resource, the Department may enter into a lake or streambed alteration agreement with the entity that includes reasonable measures necessary to protect the fish or wildlife resource (Fish & G. Code, §1602, subd. (a)(4)(B)). A lake or stream alteration agreement does not authorize take of species listed as candidates, threatened, or endangered under CESA (see Protection Afforded by Listing for CESA compliance requirements).

Medicinal and Adult-Use Cannabis Regulation and Safety Act

The commercial cannabis cultivation industry is unique in that any entity applying for an annual cannabis cultivation license from California Department of Food and Agriculture (CDFA) must include "a copy of any final lake or streambed alteration agreement…or written verification from the California Department of Fish and Wildlife that a lake or streambed alteration agreement is not required" with their license application (Cal. Code Regs., tit. 3, § 8102, subd. (v)). The SWRCB also enforces the laws related to waste discharge and water diversions associated with cannabis cultivation (Cal. Code Regs., tit. 3, § 8102, subd. (p)).

Forest Practice Act

The Forest Practice Act was originally enacted in 1973 to ensure that logging in California is undertaken in a manner that will also preserve and protect the State's fish, wildlife, forests, and streams. This law and the regulations adopted by the California Board of Forestry and Fire Protection (BOF) pursuant to it are collectively referred to as the Forest Practice Rules. The Forest Practice Rules implement the provisions of the Forest Practice Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. The California Department of Forestry and Fire Protection (CAL FIRE) enforces these laws and regulations governing logging on private land.

Federal Power Act

The Federal Power Act and its major amendments are implemented and enforced by FERC and require licenses for dams operated to generate hydroelectric power. One of the major amendments required that these licenses "shall include conditions for the protection, mitigation and enhancement of fish and wildlife including related spawning grounds and habitat" (ECPA 1986). Hydropower licenses granted by FERC are usually valid for 30-50 years. If a licensee wants to renew their license, it must file a Notice of Intent and a pre-application document five years before the license expires to provide time for public scoping, any potentially new studies necessary to analyze project impacts and alternatives, and preparation of environmental documents. The applicant must officially apply for the new license at least two years before the current license expires.

As a federal agency, FERC must comply with federal environmental laws prior to issuing a new license or relicensing an existing hydropower project, which includes NEPA and ESA. As a result of environmental compliance or settlement agreements formed during the relicensing process, some operations have been modified and habitat restored to protect fish and wildlife. For example, the Lewiston Dam relicensing resulted in establishment of the Trinity River Restoration Program, which takes an ecosystem-approach to studying dam effects and protecting and restoring fish and wildlife populations downstream of the dam (Snover and Adams 2016). Similarly, relicensing of the Rock Creek-Cresta Project on the North Fork Feather River resulted in establishment of a multi-stakeholder Ecological Resources Committee (ERC). As a result of the ERC's studies and recommendations, pulse flows for whitewater boating were suspended for several years following declines of Foothill Yellow-legged Frogs, and the ERC is currently working toward augmenting the population in an attempt to increase abundance to a viable level.

Administrative and Regional Plans

Forest Plans

NORTHWEST FOREST PLAN

In 1994, BLM and the Forest Service adopted the Northwest Forest Plan to guide the management of over 97,000 km^2 (37,500 mi^2) of federal lands in portions of northwestern California, Oregon, and Washington. The Northwest Forest Plan created an extensive network of forest reserves including

Riparian Reserves. Riparian Reserves apply to all land designations to protect riparian dependent resources. With the exception of silvicultural activities consistent with Aquatic Conservation Strategy objectives, timber harvest is not permitted within Riparian Reserves, which can vary in width from 30 to 91 m (100-300 ft) on either side of streams, depending on the classification of the stream or waterbody (USFS and BLM 1994). Fuel treatment and fire suppression strategies and practices implemented within these areas are designed to minimize disturbance.

Sierra Nevada Forest Plan

Land and Resource Management Plans for forests in the Sierra Nevada were changed in 2001 by the Sierra Nevada Forest Plan Amendment and subsequently adjusted via a supplemental Environmental Impact Statement and Record of Decision in 2004, referred to as the Sierra Nevada Framework (USFS 2004). This established an Aquatic Management Strategy with Goals including maintenance and restoration of habitat to support viable populations of riparian-dependent species; spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction; instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats; the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity; and prevention of new introductions of invasive species and reduction of invasive species impacts that adversely affect the viability of native species. The Sierra Nevada Framework also includes Riparian Conservation Objectives and associated standards and guidelines specific to aquatic-dependent species, including the Foothill Yellow-legged Frog.

Resource Management Plans

Sequoia, Kings Canyon, and Yosemite National Parks fall within the historical range of the Foothill Yellow-legged Frog, but the species has been extirpated from these areas. The guiding principles for managing biological resources on National Park Service lands include maintenance of animal populations native to park ecosystems (Hayes et al. 2016). They also commit the agency to work with other land managers on regional scientific and planning efforts and maintenance or reintroduction of native species to the parks including conserving Foothill Yellow-legged Frogs in the Sierra Nevada (USDI NPS 1999 as cited in Hayes et al. 2016). A Sequoia and Kings Canyon National Parks Resource Management Plan does not include specific management goals for Foothill Yellow-legged Frogs, but it does include a discussion of the factors leading to the species' decline and measures to restore the integrity of aquatic ecosystems (Ibid.). The Yosemite National Park Resource Management Plan includes a goal of restoring Foothill Yellow-legged Frogs to the Upper Tuolumne River below Hetch Hetchy Reservoir (USDI NPS 2003 as cited in Hayes et al. 2016).

FERC Licenses

Dozens of hydropower dams have been relicensed in California since 1999, and several are in the process of relicensing (FERC 2019). In addition to following the Federal Power Act and other applicable federal laws, Porter-Cologne Water Quality Act requires non-federal dam operators to obtain a Water Quality Certification (WQC) from the SWRCB. Before it can issue the WQC, the SWRCB must consult with

the Department regarding the needs of fish and wildlife. Consequently, SWRCB includes conditions in the WQC that seek to minimize adverse effects to native species, and Foothill Yellow-legged Frogs have received some special considerations due to their sensitivity to dam operations during these licensing processes. As discussed above, the typical outcome is formation of an ERC-type group to implement the environmental compliance requirements and recommend changes to flow management to reduce impacts. Foothill Yellow-legged Frog-specific requirements fall into three general categories: data collection, modified flow regimes, and standard best management practices.

Data Collection

When little is known about the impacts of different flows and temperatures on Foothill Yellow-legged Frog occupancy and breeding success, data are collected and analyzed to inform recommendations for future modifications to operations such as temperature trigger thresholds. These surveys include locating egg masses and tadpoles, monitoring temperatures and flows, and recording their fate (e.g., successful development and metamorphosis, displacement, desiccation) during different flow operations and different water years. Examples of licenses with these conditions include the Lassen Lodge Project (FERC 2018), Rock Creek-Cresta Project (FERC 2009a), and El Dorado Project (EID 2007).

Modified Flow Regimes

When enough data exist to understand the effect of different operations on Foothill Yellow-legged Frog occupancy and success, license conditions may include required minimum seasonal instream flows, specific thermal regimes, gradual ramping rates to reduce the likelihood of early life stage scour or stranding, or freshet releases (winter/spring flooding simulation) to maintain riparian processes, and cancellation or prohibition of recreational pulse flows during the breeding season. Examples of licenses with these conditions include the Poe Hydroelectric Project (SWRCB 2017), Upper American Project (FERC 2014), and Pit 3, 4, 5 Project (FERC 2007b).

Best Management Practices

Efforts to reduce the impacts from maintenance activities and indirect operations include selective herbicide and pesticide application, aquatic invasive species monitoring and control, erosion control, and riparian buffers. Examples of licenses with these conditions include the South Feather Project (SWRCB 2018), Spring Gap-Stanislaus Project (FERC 2009b), and Chili Bar Project (FERC 2007a).

Habitat Conservation Plans and Natural Community Conservation Plans

Non-federal entities can obtain authorization for take of federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of a Habitat Conservation Plan (HCP) pursuant to Section 10 of the ESA. The take authorization can extend to species not currently listed under ESA but which may become listed as threatened or endangered over the term of the HCP, which is often 25-75 years. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. A Natural Community Conservation Plan (NCCP) identifies and provides for the protection of plants, animals, and their

habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs that include Foothill Yellow-legged Frogs as a covered species, two of which are also NCCPs.

Humboldt Redwood (formerly Pacific Lumber) Company

The Humboldt Redwood Company (HRC) HCP covers 85,672 ha (211,700 ac) of private Coast Redwood and Douglas-fir forest in Humboldt County (HRC 2015). It is a 50-year HCP/incidental take permit (ITP) that was executed in 1999, revised in 2015 as part of its adaptive management strategy, and expires on March 1, 2049. The HCP includes an Amphibian and Reptile Conservation Plan and an Aquatics Conservation Plan with measures designed to sustain viable populations of Foothill Yellow-legged Frogs and other covered aquatic herpetofauna. These conservation measures include prohibiting or limiting tree harvest within Riparian Management Zones (RMZ), controlling sediment by maintaining roads and hillsides, restricting controlled burns to spring and fall in areas outside of the RMZ, conducting effectiveness monitoring throughout the life of the HCP, and use the data collected to adapt monitoring and management plans accordingly.

Watershed assessment surveys include observations of Foothill Yellow-legged Frogs and have documented their widespread distribution on HRC lands with a pattern of fewer near the coast in the fog belt and more inland (S. Chinnici pers. comm. 2017). The watersheds within the property are largely unaffected by dam-altered flow regimes or non-native species, so aside from the operations described under Timber Harvest above that are minimized to the extent feasible, the focus on suitable temperatures and denser canopy cover for salmonids may reduce habitat suitability for Foothill Yellow-legged Frogs over time (Ibid.).

San Joaquin County Multi-Species Habitat Conservation and Open Space Plan

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) is a 50-year HCP/ITP that was signed by the USFWS on November 14, 2000 (San Joaquin County 2000). The SJMSCP covers almost all of San Joaquin County except federal lands, a few select projects, and some properties with certain land uses, roughly 364,000 ha (900,000 ac). At the time of execution, approximately 70 ha (172 ac) of habitat within the SJMSCP area in the southwest portion of the county were considered occupied by Foothill Yellow-legged Frogs with another 1,815 ha (4,484 ac) classified as potential habitat, but it appears the species had been considered extirpated before then (Jennings and Hayes 1994, San Joaquin County 2000, Lind 2005). The HCP estimates around 8% of the combined modeled habitat would be converted to other uses over the permit term, but the establishment of riparian preserves with buffers around Corral Hollow Creek, where the species occurred historically, was expected to offset those impacts (San Joaquin County 2000, SJCOG 2018). However, the HCP did not require surveys to determine if Foothill Yellow-legged Frogs are benefiting (M. Grefsrud pers. comm. 2019).

East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan

The East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan (ECCC HCP/NCCP) is a multi-jurisdictional 30-year plan adopted in 2007 that covers over 70,423 ha (174,018 ac) in eastern Contra Costa County (Jones & Stokes 2006). The Foothill Yellow-legged Frog appears to be

extirpated from the ECCC HCP/NCCP area (CNDDB 2019). Nevertheless, suitable habitat was mapped, and impacts were estimated at well under 1% of both breeding and migratory habitat (Jones & Stokes 2006). One of the HCP/NCCP's objectives is acquiring high-quality Foothill Yellow-legged Frog habitat that has been identified along Marsh Creek (Ibid.). In 2017, the Viera North Peak 65 ha (160 ac) property was acquired that possesses suitable habitat for Foothill Yellow-legged Frogs (ECCCHC 2018).

Santa Clara Valley Habitat Plan

The Santa Clara Valley Habitat Plan (SCVHP) is a 50-year HCP/NCCP covering over 210,237 ha (519,506 ac) in Santa Clara County (ICF 2012). As previously mentioned, Foothill Yellow-legged Frogs appear to have been extirpated from lower elevation sites, particularly below reservoirs in this area. Approximately 17% of modeled Foothill Yellow-legged Frog habitat, measured linearly along streams, was already permanently preserved, and the SCVHP seeks to increase that to 32%. The maximum allowable habitat loss is 11 km (7 mi) permanent loss and 3 km (2 mi) temporary loss, while 167 km (104 mi) of modeled habitat is slated for protection. By mid-2018, 8% of impact area had been accrued and 3% of habitat protected (SCVHA 2019).

Green Diamond Aquatic Habitat Conservation Plan

Green Diamond Resources Company has an Aquatic Habitat Conservation Plan (AHCP) covering 161,875 ha (400,000 ac) of their land that is focused on cold-water adapted species, but many of the conservation measures are expected to benefit Foothill Yellow-legged Frogs as well (K. Hamm pers. comm. 2017). Examples include slope stability and road management measures to reduce stream sedimentation from erosion and landslides, and limiting water drafting during low flow periods with screens over the pumps to avoid entraining animals (Ibid.). Although creating more open canopy areas and warmer water temperatures is not the goal of the AHCP, the areas that are suitable for Foothill Yellow-legged Frog breeding are likely to remain that way because they are wide channels that receive sufficient sunlight (Ibid.).

SUMMARY OF LISTING FACTORS

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CESA's implementing regulations identify key factors relevant to the Department's analyses and the Fish and Game Commission's decision on whether to list a species as threatened or endangered. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

Present or Threatened Modification or Destruction of Habitat

Most of the factors affecting ability to survive and reproduce listed above involve destruction or degradation of Foothill Yellow-legged Frog habitat. The most widespread, and potentially most significant, threats are associated with dams and their flow regimes, particularly in areas where they are concentrated and occur in a series along a river. Dams and the way they are operated can have up- and downstream impacts to Foothill Yellow-legged Frogs. They can result in confusing natural breeding cues, scouring and stranding of egg masses and tadpoles, reducing quality and quantity of breeding and rearing habitat, reducing tadpole growth rate, impeding gene flow among populations, and establishing and spreading non-native species (Hayes et al. 2016). These impacts appear to be most severe when the dam is operated for the generation of hydropower utilizing hydropeaking and pulse flows (Kupferberg et al. 2009c, Peek 2018). Foothill Yellow-legged Frog abundance below dams is an average of five times lower than in unregulated rivers (Kupferberg et al. 2012). The number, height, and distance upstream of dams in a watershed influenced whether Foothill Yellow-legged Frogs still occurred at sites where they had been present in 1975 in California (Ibid.). Water diversions for agricultural, industrial, and municipal uses also reduce the availability and quality of Foothill Yellow-legged Frog habitat. Dams are concentrated in the Bay Area, Sierra Nevada, and southern California (Figure 17), while hydropower plants are densest in the northern and central Sierra Nevada (Figure 18).

With predicted increases in the human population, ambitious renewable energy targets, higher temperatures, and more extreme and variable precipitation falling increasingly more as rain rather than snow, the need for more and taller dams and water diversions for hydroelectric power generation, flood control, and water storage and delivery is not expected to abate in the future. California voters approved Proposition 1, the Water Quality, Supply and Infrastructure Improvement Act of 2014, which dedicated $2.7 billion to water storage projects (PPIC 2018). In 2018, the California Water Commission approved funding for four new dams in California: expansion of Pacheco Reservoir (Santa Clara County), expansion of Los Vaqueros Reservoir (Contra Costa County), Temperance Flat Dam (new construction) on the San Joaquin River (Fresno County), and the off-stream Sites Reservoir (new construction) diverting the Sacramento River (Colusa County) (CWC 2019). No historical records of Foothill Yellow-legged Frogs from the Los Vaqueros or Sites Reservoir areas exist in the CNDDB, and one historical (1950) collection is documented from the Pacheco Reservoir area (CNDDB 2019). However, the proposed Temperance Flat Dam site is downstream of one of the only known extant populations of Foothill Yellow-legged Frogs in the East/Southern Sierra clade (Ibid.).

The other widespread threat to Foothill Yellow-legged Frog habitat is climate change, although the severity of its impacts is somewhat uncertain. While drought, wildland fires, floods, and landslides are natural and ostensibly necessary disturbance events for preservation of native biodiversity, climate change is expected to result in increased frequency and severity of these events in ways that may exceed species' abilities to adapt (Williams et al. 2008, Hoffmann and Sgrò 2011, Keely and Syphard 2016). These disturbance events which can lead to local extirpations will occur across a landscape of fragmented and small populations and thus the likelihood of natural recolonization will be highly impaired. Climatic~~These c~~hanges in flow regime can lead to increased competition, predation, and disease transmission as species become concentrated in areas that remain wet into the late summer

(Adams et al. 2017a, Kupferberg and Catenazzi 2019). Loss of riparian vegetation from wildland fires can result in increased stream temperatures or concentrations of nutrients and trace heavy metals that inhibit growth and survival (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Stream sedimentation from landslides following fire or excessive precipitation can destroy or degrade breeding and rearing habitat (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). At least some models predict unprecedented dryness in the latter half of the century (Cook et al. 2015). The effects of climate change will be realized across the Foothill Yellow-legged Frog's range, and their severity will likely differ in ways that are difficult to predict. However, the impacts from extended droughts will likely be greatest in the areas that are naturally more arid, the lower elevations and latitudes of southern California and the foothills surrounding the Central Valley (Figure 21).

While most future urbanization is predicted to occur in areas outside of the Foothill Yellow-legged Frog's range, it has already contributed to the loss and fragmentation of Foothill Yellow-legged Frog habitat in California. In addition, the increased predation, wildland fires, introduced species, road mortality, disease transmission, air and water pollution, and disturbance from recreation that can accompany urbanization expand its impact far beyond its physical footprint (Davidson et al. 2002, Syphard et al. 2007, Cook et al. 2012, Bar-Massada et al. 2014). Within the Foothill Yellow-legged Frog's historical range, these effects appear most significant and extensive in terms of population extirpations in southern California and the San Francisco Bay Area.

Several other activities have the potential to destroy or degrade Foothill Yellow-legged Frog habitat, but they are less common across the range. They also tend to have relatively small areas of impact, although they can be significant in those areas, particularly if populations are already small and declining. These include impacts from mining, cannabis cultivation, vineyard expansion, overgrazing, timber harvest, recreation, and some stream habitat restoration projects (Harvey and Lisle 1998, Belsky et al. 1999, Merelender 2000, Pilliod et al. 2003, Bauer et al. 2015, Kupferberg and Furey 2015).

Overexploitation

Foothill Yellow-legged Frogs are not threatened by overexploitation. There is no known pet trade for Foothill Yellow-legged Frogs (Lind 2005). During the massive frog harvest that accompanied the Gold Rush, some Foothill Yellow-legged Frogs were collected, but because they are relatively small and have irritating skin secretions, there was much less of a market for them (Jennings and Hayes 1985). Within these secretions is a peptide with antimicrobial activity that is particularly potent against *Candida albicans*, a human pathogen that has been developing resistance to traditional antifungal agents (Conlon et al. 2003). However, the peptide's therapeutic potential is limited by its strong hemolytic activity, so further studies will focus on synthesizing analogs that can be used as antifungals, and collection of Foothill Yellow-legged Frogs for lab cultures is unlikely (Ibid.).

Like all native California amphibians, collection of Foothill Yellow-legged Frogs is unlawful without a permit from the Department. They may only be collected for scientific, educational, or propagation reasons through a Scientific Collecting Permit (Fish & G. Code § 1002 et seq.). The Department has the discretion to limit or condition the number of individuals collected or handled to ensure no significant adverse effects. Incidental harm from authorized activities on other aquatic species can be avoided or minimized by the inclusion of special terms and conditions in permits.

Predation

Predation is a likely contributor to Foothill Yellow-legged Frog population declines where the habitat is degraded by one or many other risk factors (Hayes and Jennings 1986). Predation by native gartersnakes can be locally substantial; however, it may only have an appreciable population-level impact if the availability of escape refugia is diminished. For example, when streams dry and only pools remain, Foothill Yellow-legged Frogs are more vulnerable to predation by native and non-native species because they are concentrated in a small area with little cover.

Several studies have demonstrated the synergistic impacts of predators and other stressors. Foothill Yellow-legged Frogs, primarily as demonstrated through studies on tadpoles, are more susceptible to predation when exposed to some agrochemicals, cold water, high velocities, excess sedimentation, and even the presence of other species of predators (Harvey and Lisle 1998, Adams et al. 2003, Olson and Davis 2009, Kupferberg et al. 2011b, Kerby and Sih 2015, Catenazzi and Kupferberg 2018). Foothill Yellow-legged Frog tadpoles appear to be naïve to chemical cues from some non-native predators; they have not evolved those species-specific predator avoidance behaviors (Paoletti et al. 2011). Furthermore, early life stages are often more sensitive to environmental stressors, making them more vulnerable to predation, and Foothill Yellow-legged Frog population dynamics are highly sensitive to egg and tadpole mortality (Kats and Ferrer, 2003, Kupferberg et al. 2009c). Predation pressure is likely positively associated with proximity to anthropogenic changes in the environment, so in more remote or pristine places, it probably does not have a serious population-level impact.

Competition

Intra- and interspecific competition in Foothill Yellow-legged Frogs has been documented. Intraspecific male-to-male competition for females has been reported (Rombough and Hayes 2007). Observations include physical aggression and a non-random mating pattern in which larger males were more often engaged in breeding (Rombough and Hayes 2007, Wheeler and Welsh 2008). A behavior resembling clutch-piracy, where a satellite male attempts to fertilize already laid eggs, has also been documented (Rombough and Hayes 2007). These acts of competition play a role in population genetics, but they likely do not result in serious physical injury or mortality. Intraspecific competition among Foothill Yellow-legged Frog tadpoles was negligible (Kupferberg 1997a).

Interspecific competition appears to have a greater possibility of resulting in adverse impacts. Kupferberg (1997a) did not observe a significant change in tadpole mortality for Foothill Yellow-legged Frogs raised with Pacific Treefrogs compared to single-species controls. However, when reared together, Foothill Yellow-legged Frog tadpoles lost mass, while Pacific Treefrog tadpoles increased mass (Kerby and Sih 2015). As described previously under Introduced Species, Foothill Yellow-legged Frog tadpoles experienced significantly higher mortality and smaller size at metamorphosis when raised with bullfrog tadpoles (Kupferberg 1997a). The mechanism of these declines appeared to be exploitative competition, as opposed to interference, through the reduction of available algal resources from bullfrog tadpole grazing in the shared enclosures (Ibid.).

The degree to which competition threatens Foothill Yellow-legged Frogs likely depends on the number and density of non-native species in the area rather than intraspecific competition, and co-occurrence of Foothill Yellow-legged Frog and bullfrog tadpoles may be somewhat rare since the latter tends to breed in lentic (still water) environments (M. van Hattem pers. comm. 2019). Interspecific competition with other native species may have some minor adverse consequences on fitness.

Disease

Currently, the only disease known to pose a serious risk to Foothill Yellow-legged Frogs is Bd. Until 2017, the only published studies on the impact of Bd on Foothill Yellow-legged Frog suggested it could reduce growth and body condition but was not lethal (Davidson et al. 2007, Lowe 2009, Adams et al. 2017b). However, two recent mass mortality events caused by chytridiomycosis proved they are susceptible to lethal effects, at least under certain conditions like drought-related concentration and presence of bullfrogs (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Some evidence indicates disease may have played a principal role in the disappearance of the species from southern California (Adams et al. 2017b). Bd is likely present in the environment~~al~~ throughout the Foothill Yellow-legged Frog's range, and with bullfrogs and treefrogs acting as carriers, it will remain a threat to the species; however, given the dynamics of the two recent die-offs in the San Francisco Bay area, the probability of future outbreaks may be greater in areas where the species is under additional stressors like drought and introduced species (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Therefore, as with predation, Foothill Yellow-legged Frogs are less likely to experience the adverse impacts of diseases in more remote areas with fewer anthropogenic changes to the environment.

Other Natural Events or Human-Related Activities

Agrochemicals, particularly organophosphates that act as endocrine disruptors, can travel substantial distances from the area of application through atmospheric drift and have been implicated in the disappearance and declines of many species of amphibians in California including Foothill Yellow-legged Frogs (LeNoir et al. 1999, Davidson 2004, Lind 2005, Olson and Davis 2009). Foothill Yellow-legged Frogs appear to be significantly more sensitive to the adverse impacts of some pesticides than other native species (Sparling and Fellers 2009, Kerby and Sih 2015). These include smaller body size, slower development rate, increased time to metamorphosis, immunosuppression, and greater vulnerability to predation and malformations (Kiesecker 2002, Hayes et al. 2006, Sparling and Fellers 2009, Kerby and Sih 2015). Some of the most dramatic declines experienced by ranids in California occurred in the Sierra Nevada east of the San Joaquin Valley where over half of the state's total pesticide usage occurs (Sparling et al. 2001).

Many Foothill Yellow-legged Frog populations are small, isolated from other populations, and possess low genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). Genetic diversity is important in providing a population the capacity to evolve in response to environmental changes, and connectivity among populations is important for gene exchange and in minimizing probability of local extinction

(Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). Small populations are at much greater risk of extirpation primarily through the disproportionate impact of demographic, environmental, and genetic stochasticity than robust populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). Based on a Foothill Yellow-legged Frog PVA, populations in regulated rivers face a 4- to 13-fold greater extinction risk in 30 years than populations in unregulated rivers due to smaller population sizes (Kupferberg et al. 2009c). The threat posed by small population sizes is significant and the general pattern shows increases in severity from north to south; however, many sites, primarily in the northern Sierra Nevada, in watersheds with large hydropower projects are also at high risk.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). The conservation, protection, and enhancement of listed species and their habitat is of statewide concern (Fish & G. Code, § 2051(c)). CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86). The Fish and Game Code provides the Department with related authority to authorize "take" of species listed as threatened or endangered under certain circumstances (see, e.g., Fish & G. Code, §§ 2081, 2081.1, 2086, & 2835).

If the Foothill Yellow-legged Frog is listed under CESA, impacts of take caused by activities authorized through incidental take permits must be minimized and fully mitigated according to state standards (Fish & G. Code, § 2081, subd. (b)). These standards typically include protection of land in perpetuity with an easement, development and implementation of a species-specific adaptive management plan, and funding through an endowment to pay for long-term monitoring and maintenance to ensure the mitigation land meets performance criteria. Obtaining an incidental take permit is voluntary. The Department cannot force compliance; however, any person violating the take prohibition may be criminally and civilly liable under state law.

Additional protection of Foothill Yellow-legged Frogs following listing would be expected to occur through state and local agency environmental review under CEQA. CEQA requires affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on rare, threatened, and endangered species. In common practice, potential impacts to listed species are examined more closely in CEQA documents than potential impacts to unlisted species. Where significant impacts are identified under CEQA, the Department expects project-specific avoidance, minimization, and mitigation measures to benefit the species. State listing, in this respect, and consultation with the Department during state and local agency environmental review under CEQA, would be expected to benefit the Foothill Yellow-legged Frog in terms of reducing impacts from individual projects, which might otherwise occur absent listing.

For some species, CESA listing may prompt increased interagency coordination and the likelihood that state and federal land and resource management agencies will allocate funds toward protection and recovery actions. In the case of the Foothill Yellow-legged Frog, some multi-agency efforts exist, often associated with FERC license requirements, to improve habitat conditions and augment declining populations. The USFWS is leading an effort to develop regional Foothill Yellow-legged Frog conservation strategies, and CESA listing may result in increased priority for limited conservation funds.

LISTING RECOMMENDATION

CESA directs the Department to prepare this report regarding the status of the Foothill Yellow-legged Frog in California based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067).

The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science. In consideration of the scientific information contained herein, the Department has determined that listing the Foothill Yellow-legged Frog under CESA by genetic clade is the prudent approach due to the disparate degrees of imperilment among them. In areas of uncertainty, the Department recommends the higher protection status until clade boundaries can be better defined.

NORTHWEST/NORTH COAST: Not warranted at this time.

Clade-level Summary: This is the largest clade with the most robust populations (highest densities) and the greatest genetic diversity. This area is the least densely populated by humans; contains relatively few hydroelectric dams, particularly further north; and has the highest precipitation in the species' California range. The species is still known to occur in most, if not all, historically occupied watersheds; presumed extirpations are mainly concentrated in the southern portion of the clade around the heavily urbanized San Francisco Bay area. The proliferation of cannabis cultivation, particularly illicit grows in and around the Emerald Triangle, the apparent increase in severe wildland fires in the area, and potential climate change effects are cause for concern, so the species should remain a Priority 1 SSC here with continued monitoring for any change in its status.

WEST/CENTRAL COAST: Endangered.

Clade-level Summary: Foothill Yellow-legged Frogs appear to be extirpated from a relatively large proportion of historically occupied sites within this clade, particularly in the heavily urbanized northern portion around the San Francisco Bay. In the northern portion of the clade, nearly all the remaining populations (which may be fewer than a dozen) are located above dams, which line the mountains surrounding the Bay Area, and two are known to have undergone recent disease-associated die-offs. These higher elevation sites are more often intermittent or ephemeral streams than the lower in the watersheds. As a result, the more frequent and extreme droughts that have dried up large areas seem to have contributed to recent declines. Illegal cannabis cultivation, historical mining effects, overgrazing, and recreation likely contributed to declines and may continue to threaten remaining populations.

SOUTHWEST/SOUTH COAST: Endangered.

Clade-level Summary: The most extensive extirpations have occurred in this clade, and only two known extant populations remain. Both are small with apparently low genetic diversity, making them especially vulnerable to extirpation. This is also an area with a large human population, many dams, and naturally arid, fire-prone environments, particularly in the southern portion of the clade. Introduced species are widespread, and cannabis cultivation is rivaling the Emerald Triangle in some areas (e.g., Santa Barbara County). Introduced species, expanded recreation, disease, and flooding appear to have contributed to the widespread extirpations in southern California over 40 years ago.

FEATHER RIVER: Threatened.

Clade-level Summary: This is the smallest clade and has a high density of hydroelectric dams. It also recently experienced one of the largest, most catastrophic wildfires in California history. Despite these threats, Foothill Yellow-legged Frogs appear to continue to be relatively broadly distributed within the clade, although with all the dams in the area, most populations are likely disconnected. The area is more mesic and experienced less of a change in precipitation in the most recent drought than the clades south of it. The clade is remarkable genetically and morphologically as it is the only area where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs overlap and can hybridize. The genetic variation within the clade is greater than the other clades except for the Northwest/North Coast. Most of the area within the clade's boundaries is Forest Service-managed, and little urbanization pressure or known extirpations exist in this area. Recent FERC licenses in this area require Foothill Yellow-legged Frog specific conservation, which to date has included cancelling pulse flows, removing encroaching vegetation, and translocating egg masses and in situ head-starting to augment a population that had recently declined.

NORTHEAST/NORTHERN SIERRA: Threatened.

Clade-level Summary: The Northeast/Northern Sierra clade shares many of the same threats as the Feather River clade (e.g., relatively small area with many hydroelectric dams). The area is also more mesic and experienced less of a change in precipitation during the recent drought than more southern clades. However, this pattern may not continue as some models suggest loss of snowmelt will be greater in the northern Sierra Nevada, and one of the climate change exposure models suggests a comparatively large proportion of the lower elevations will experience climatic conditions not currently known from the area (i.e., non-analog) by the end of the century. Recent surveys suggest the area continues to support several populations of the species, some of which seem to remain robust, with a fairly widespread distribution. However, genetic analyses from several watersheds suggest many of these populations are isolated and diverging, particularly in regulated reaches with hydropeaking flows.

EAST/SOUTHERN SIERRA: Endangered.

Clade-level Summary: Like the Southwest/South Coast clade, widespread extirpations in this area were observed as early as the 1970s. Dams and introduced species were credited as causal factors in these declines in distribution and abundance, and mining and disease may also have contributed. This area is relatively arid, and drought effects appear greater here than in northern areas that exhibit both more precipitation and a smaller difference between drought years and the historical average. There is a relatively high number of hydroelectric power generating dams in series along the major rivers in this clade and at least one new proposed dam near one of the remaining populations. This area is also the most heavily impacted by agrochemicals from the San Joaquin Valley.

MANAGEMENT RECOMMENDATIONS

The Department has evaluated existing management recommendations and available literature applicable to the management and conservation of the Foothill Yellow-legged Frog to arrive at the following recommendations. These recommendations, which represent the best available scientific information, are largely derived the from the Foothill Yellow-legged Frog Conservation Assessment, the California Energy Commission's Public Interest Energy Research Reports, the Recovery Plans of West Coast Salmon and Steelhead, and the California Amphibian and Reptile Species of Special Concern (Kupferberg et al. 2009b,c; 2011a; NMFS 2012, 2013, 2014, 2016; Hayes et al. 2016, Thomson et al. 2016).

Conservation Strategies

Maintain current distribution and genetic diversity by protecting existing Foothill Yellow-legged Frog populations and their habitats and providing opportunities for genetic exchange. Increase abundance to viable levels in populations at risk of extirpation due to small sizes, when appropriate, through in situ or ex situ captive rearing and/or translocations. Use habitat suitability and hydrodynamic habitat models to identify historically occupied sites that may currently support Foothill Yellow-legged Frogs, or they could with minor habitat improvements or modified management. Re-establish extirpated populations in suitable habitat through captive propagation, rearing, and/or translocations. Prioritize areas in the southern portions of the species' range where extirpations and loss of diversity have been the most severe.

If establishing reserves, prioritize areas containing high genetic variation in Foothill Yellow-legged Frogs (and among various native species) and climatic gradients where selection varies over small geographical area because environmental heterogeneity can provide a means of maintaining phenotypic variability which increases the adaptive capacity of populations as conditions change. These reserves should provide connectivity to other occupied areas to facilitate gene flow and allow for ongoing selection to fire, drought, thermal stresses, and changing species interactions.

Research and Monitoring

Attempt to rediscover potentially remnant populations in areas where they are considered extirpated, prioritizing the southern portions of the species' range. Collect environmental DNA in addition to conducting visual encounter surveys to improve detectability. Concurrently assess presence of threats and habitat suitability to determine if future reintroductions may be possible. Collect genetic samples from any Foothill Yellow-legged Frogs captured for use in landscape genomics analyses and possible future translocation or captive propagation efforts. Attempt to better clarify clade boundaries where there is uncertainty. Study whether small populations are at risk of inbreeding depression, whether genetic rescue should be attempted, and if so, whether that results in hybrid vigor or outbreeding depression.

Continue to evaluate how water operations affect Foothill Yellow-legged Frog population demographics. Support, and coordinate existing monitoring and ~~Establish~~ establish more long-term monitoring programs in regulated and unregulated (reference) rivers across the species' range but particularly in areas like the Sierra Nevada where most large hydropower dams in the species' range are concentrated. Assess whether the timing of pulse flows influences population dynamics, particularly whether early releases have a disproportionately large adverse effect by eliminating the reproductive success of the largest, most fecund females, who appear to breed earlier in the season. Investigate survival rates in poorly-understood life stages, such as tadpoles, young of the year, and juveniles. Determine the extent to which pulse flows contribute to displacement and mortality of post-metamorphic life stages.

Collect habitat variables that correlate with healthy populations to develop more site-specific habitat suitability and hydrodynamic models. Study the potential synergistic effect of increased flow velocity and decreased temperature on tadpole fitness. Examine the relationship between changes in flow, breeding and rearing habitat connectivity, and scouring and stranding to develop site-specific benign ramping rates. Incorporate these data and demographic data into future PVAs for use in establishing frog-friendly flow regimes in future FERC relicensing or license amendment efforts and habitat restoration projects. Ensure long-term funding for post-license or restoration monitoring to evaluate attainment of expected results and for use in adapting management strategies accordingly.

Evaluate the distribution of other threats such as cannabis cultivation, vineyard expansion, livestock grazing, mining, timber harvest, and urbanization and roads in the Foothill Yellow-legged Frog's range. Study the short- and long-term effects of wildland fires and fire management strategies. Assess the extent to which these potential threats pose a risk to Foothill Yellow-legged Frog persistence in both regulated and unregulated systems.

Investigate how reach-level or short-distance habitat suitability and hydrodynamic models can be extrapolated to a watershed level. Study habitat connectivity needs such as the proximity of breeding sites and other suitable habitats along a waterway necessary to maintain gene flow and functioning meta-population dynamics.

Habitat Restoration and Watershed Management

Remove or update physical barriers like dams and poorly constructed culverts and bridges to improve connectivity and natural stream processes. Remove anthropogenic features that support introduced predators and competitors such as abandoned mine tailing ponds that support bullfrog breeding. Conduct active eradication and management efforts to decrease the abundance of bullfrogs, non-native fish, and crayfish (where they are non-native). In managed rivers, manipulate stream flows to negatively affect non-native species not adapted to a winter flood/summer drought flow regime.

Adopt a multi-species approach to channel restoration projects and managed flow regimes (thermal, velocity, timing) and mimic the natural hydrograph to the greatest extent possible. When this is impractical or infeasible, focus on minimizing adverse impacts by gradually ramping discharge up and down, creating and maintaining gently sloping and sun-lit gravel bars and warm calm edgewater habitats for tadpole rearing, and mixing hypolimnetic water (from the lower colder stratum in a reservoir) with warmer surface water before release if necessary to ensure appropriate thermal conditions for successful metamorphosis. Promote restoration and maintenance of habitat heterogeneity (different depths, velocities, substrates, etc.) and connectivity to support all life stages and gene flow. Avoid damaging Foothill Yellow-legged Frog breeding habitat when restoring habitat for other focal species like anadromous salmonids.

Regulatory Considerations and Best Management Practices

Develop range-wide minimum summer baseflow requirements that protect Foothill Yellow-legged Frogs and their habitat with appropriate provisions to address regional differences using new more ecologically-meaningful approaches such as modified percent-of-flow strategies for watersheds (e.g., Mierau et al. 2018). Limit water diversions during the dry season and construction of new dams by focusing on off-stream water storage strategies.

Ensure and improve protection of riparian systems. Require maintenance of appropriate riparian buffers and canopy coverage (i.e., partly shaded) around occupied habitat or habitat that has been identified for potential future reintroductions. Restrict instream work to dry periods where possible. Prohibit fording in and around breeding habitat. Avoid working near streams after the first major rains in the fall when Foothill Yellow-legged Frogs may be moving upslope toward tributaries and overwintering sites. Use a 3 mm (0.125 in) mesh screen on water diversion pumps and limit the rate and amount of water diverted such that depth and flow remain sufficient to support Foothill Yellow-legged Frogs of all life stages occupying the immediate area and downstream. Install exclusion fencing where appropriate (being mindful of predators, such as river otters, that may take advantage of fencing to catch frogs). I~~, and i~~f Foothill Yellow-legged Frog relocation is required, conduct it early in the season because moving egg masses is easier than moving tadpoles.

Reduce habitat degradation from sedimentation, pesticides, herbicides, and other non-point source waste discharges from adjacent land uses including along tributaries of rivers and streams. Limit mining to parts of rivers not used for oviposition, such as deeper pools or reaches with few tributaries, and at times of year when frogs are more common in tributaries (i.e., fall and winter). Manage recreational activities in or adjacent to Foothill Yellow-legged Frog habitat (e.g., OHV and hiking trails, camp sites, boating ingress/egress, flows, and speeds) in a way that minimizes adverse impacts. Siting cannabis grows in areas with better access to roads, gentler slopes, and ample water resources could significantly reduce threats to the environment. Determine which, when, and where agrochemicals should be restricted to reduce harm to Foothill Yellow-legged Frogs and other species. Ensure all new road crossings and upgrades to existing crossings (bridges, culverts, fills, and other crossings) accommodate at least 100-year flood flows and associated bedload and debris.

Partnerships and Coordination

Establish collaborative partnerships with agencies, universities, and non-governmental organizations working on salmon and steelhead recovery and stream restoration. Anadromous salmonids share many of the same threats as Foothill Yellow-legged Frogs, and recovery actions such as barrier removal, restoration of natural sediment transport processes, reduction in pollution, and eradication of non-native predators ~~would~~ should be planned so as to benefit frogs as well. Ensure Integrated Regional Water Management Plans and fisheries restoration programs take Foothill Yellow-legged Frog conservation into consideration during design, implementation, and maintenance.

Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems. Promote and implement initiatives and programs that improve water conservation use efficiency, reduce greenhouse gas emissions, promote sustainable agriculture and smart urban growth, and protect and restore riparian ecosystems. Shift reliance from on-stream storage to off-stream storage, resolve frost protection issues (water withdrawals), and ensure necessary flows for all life stages in all water years.

Establish a Department-coordinated staff and citizen scientist program to systematically monitor occupied stream reaches across the species' range.

Education and Enforcement

Support programs to provide educational outreach and local involvement in restoration and watershed stewardship, such as Project Wild, Adopt a Watershed, school district environmental camps, and other programs teaching the effects of human land and water use on Foothill Yellow-legged Frog survival.

Provide additional funding for increased law enforcement to reduce ecologically harmful stream alterations and water pollution and to ensure adequate protection for Foothill Yellow-legged Frogs at pumps and diversions. Identify and address illegal water diverters and out-of-compliance diverters, seasons of diversion, off-stream reservoirs, well pumping, and bypass flows to protect Foothill Yellow-legged Frogs. Prosecute violators accordingly.

ECONOMIC CONSIDERATIONS

The Department is charged in an advisory capacity in the present context to provide a written report and a related recommendation to the Commission based on the best scientific information available regarding the status of Foothill Yellow-legged Frog in California. The Department is not required to prepare an analysis of economic impacts (See Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

REFERENCES

Literature Cited

Ackerly, D., A. Jones, M. Stacey, and B. Riordan. 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.

Adams, A.J., S.J. Kupferberg, M.Q. Wilber, A.P. Pessier, M. Grefsrud, S. Bobzien, V.T. Vredenburg, and C.J. Briggs. 2017a. Extreme Drought, Host Density, Sex, and Bullfrogs Influence Fungal Pathogen Infections in a Declining Lotic Amphibian. Ecosphere 8(3):e01740. DOI: 10.1002/ecs2.1740.

Adams, A.J., A.P. Pessier, and C.J. Briggs. 2017b. Rapid Extirpation of a North American Frog Coincides with an Increase in Fungal Pathogen Prevalence: Historical Analysis and Implications for Reintroduction. Ecology and Evolution 7(23):10216-10232. DOI: 10.1002/ece3.3468

Adams, M.J., C.A. Pearl, and R.B. Bury. 2003. Indirect Facilitation of an Anuran Invasion by Non-native Fishes. Ecology Letters 6:343-351.

Allen, M., and S. Riley. 2012. Effects of Electrofishing on Adult Frogs. Unpublished report prepared by Normandeau Associates, Inc., Arcata, CA.

Alpers, C.N., M.P. Hunerlach, J.T. May, R.L. Hothem, H.E. Taylor, R.C. Antweiler, J.F. De Wild, and D.A. Lawler. 2005. Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999–2001: U.S. Geological Survey Scientific Investigations Report 2004-5251.

Alston, J.M., J.T. Lapsley, and O. Sambucci. 2018. Grape and Wine Production in California. Pp. 1-28 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/a1/1e/a11eb90f-af2a-4deb-ae58-9af60ce6aa40/grape_and_wine_production.pdf

American Bankers Association [ABA]. 2019. Marijuana and Banking. Website accessed on April 5, 2019 at https://www.aba.com/advocacy/issues/pages/marijuana-banking.aspx

Ashton, D.T. 2002. A Comparison of Abundance and Assemblage of Lotic Amphibians in Late-Seral and Second-Growth Redwood Forests in Humboldt County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Ashton, D.T., J.B. Bettaso, and H.H. Welsh, Jr. 2010. Foothill Yellow-legged Frog (*Rana boylii*) Distribution and Phenology Relative to Flow Management on the Trinity River. Oral presentation provided at the Trinity River Restoration Program's 2010 Trinity River Science Symposium 13 January 2010. http://www.trrp.net/library/document/?id=410

Ashton, D.T., A.J. Lind, and K.E. Schlick. 1997. Foothill Yellow-Legged Frog (*Rana boylii*) Natural History. USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA.

Ashton, D.T., and R.J. Nakamoto. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 38(4):442.

Baird, S.F. 1854. Descriptions of New Genera and Species of North American Frogs. Proceedings of the Academy of Natural Sciences of Philadelphia 7:62.

Bar-Massada, A., V.C. Radeloff, and S.I. Stewart. 2014. Biotic and Abiotic Effects of Human Settlements in the Wildland–Urban Interface. BioScience 64(5):429–437.

Bauer S.D., J.L. Olson, A.C. Cockrill, M.G. van Hattem, L.M. Miller, M. Tauzer, and G. Leppig. 2015. Impacts of Surface Water Diversions for Marijuana-Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLoS ONE 10(3):e0120016. https://doi.org/10.1371/journal.pone.0120016

Bee, M.A., and E.M. Swanson. 2007. Auditory Masking of Anuran Advertisement Calls by Road Traffic Noise. Animal Behaviour 74:1765-1776.

Beebee, T.J.C. 1995. Amphibian Breeding and Climate. Nature 374:219-220.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing in the Riparian Zone: Impact and Management Perspectives. Pp. 184-189 *In* R.D. Johnson and J.F. McCormick (Technical Coordinators). Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, U.S. Department of Agriculture, Forest Service, General Technical Report WO-12.

Belsky, A.J, A. Matzke, and S. Uselman. 1999. Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States. Journal of Soil and Water Conservation 54(1):419-431.

Blaustein, A.R., D.G. Hokit, R.K. O'Hara and R.A. Holt. 1994. Pathogenic Fungus Contributes to Amphibian Losses in the Pacific Northwest. Biological Conservation 67(3):251-254.

Bobzien, S., and J.E. DiDonato. 2007. The Status of the California Tiger Salamander (*Ambystoma californiense*), California Red-Legged Frog (*Rana draytonii*), Foothill Yellow-Legged Frog (*Rana boylii*), and Other Aquatic Herpetofauna in the East Bay Regional Park District, California. Unpublished report. East Bay Regional Park District, Oakland, CA.

Bondi, C.A., S.M. Yarnell, and A.J. Lind. 2013. Transferability of Habitat Suitability Criteria for a Stream Breeding Frog (*Rana boylii*) in the Sierra Nevada, California. Herpetological Conservation and Biology 8(1):88-103.

Bourque, R.M. 2008. Spatial Ecology of an Inland Population of the Foothill Yellow-Legged Frog (*Rana boylii*) in Tehama County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Bourque, R.M., and J.B. Bettaso. 2011. *Rana boylii* (Foothill Yellow-legged Frogs). Reproduction. Herpetological Review 42(4):589.

Brattstrom, B.H. 1962. Thermal Control of Aggregation Behavior in Tadpoles. Herpetologica 18(1):38-46.

Breedvelt, K.G.H., and M.J. Ellis. 2018. Foothill Yellow-legged Frog (*Rana boylii*) Growth, Longevity, and Population Dynamics from a 9-Year Photographic Capture-Recapture Study. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Brehme, C.S., S.A. Hathaway, and R.N. Fisher. 2018. An Objective Road Risk Assessment Method for Multiple Species: Ranking 166 Reptiles and Amphibians in California. Landscape Ecology 33:911-935. DOI: 10.1007/s10980-018-0640-1

Brode, J.M., and R.B. Bury. 1984. The Importance of Riparian Systems to Amphibians and Reptiles. Pp. 30-36 *In* R. E. Warner and K. M. Hendrix (Editors). Proceedings of the California Riparian Systems Conference, University of California, Davis.

Bursey, C.R., S.R. Goldberg, and J.B. Bettaso. 2010. Persistence and Stability of the Component Helminth Community of the Foothill Yellow-Legged Frog, *Rana boylii* (Ranidae), from Humboldt County, California, 1964–1965, Versus 2004–2007. The American Midland Naturalist 163(2):476-482. https://doi.org/10.1674/0003-0031-163.2.476

Burton, C.A., T.M. Hoefen, G.S. Plumlee, K.L. Baumberger, A.R. Backlin, E. Gallegos, and R.N. Fisher. 2016. Trace Elements in Stormflow, Ash, and Burned Soil Following the 2009 Station Fire in Southern California. PLoS ONE 11(5):e0153372. DOI: 10.1371/journal.pone.0153372

Bury, R.B. 1972. The Effects of Diesel Fuel on a Stream Fauna. California Department of Fish and Game Bulletin 58:291-295.

Bury, R.B., and N.R. Sisk. 1997. Amphibians and Reptiles of the Cow Creek Watershed in the BLM-Roseburg District. Draft report submitted to BLM-Roseburg District and Oregon Department of Fish and Wildlife-Roseburg. Biological Resources Division, USGS, Corvallis, OR.

Butsic, V., and J.C. Brenner. 2016. Cannabis (*Cannabis sativa* or *C. indica*) Agriculture and the Environment: A Systematic, Spacially-explicit Survey and Potential Impacts. Environmental Research Letters 11(4):044023.

California Department of Fish and Wildlife [CDFW]. 2018a. Considerations for Conserving the Foothill Yellow-Legged Frog. California Department of Fish and Wildlife; 5/14/2018. http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=157562

California Department of Fish and Wildlife [CDFW]. 2018b. Green Diamond Resource Company Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-026-01. Northern Region, Eureka, CA.

California Department of Fish and Wildlife [CDFW]. 2018c. Humboldt Redwood Company Foothill Yellow-legged Frog Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-039-01. Northern Region, Eureka, CA.

California Department of Food and Agriculture [CDFA]. 2018. California Grape Acreage Report, 2017 Summary.
https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Acreage/2018/201804grpacSUMMARY.pdf

California Department of Forestry and Fire Protection [CAL FIRE]. 2019. Top 20 Largest California Wildfires. http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf

California Department of Pesticide Regulation [CDPR]. 2018. The Top 100 Sites Used by Pounds of Active Ingredients Statewide in 2016 (All Pesticides Combined).
https://www.cdpr.ca.gov/docs/pur/pur16rep/top_100_sites_lbs_2016.pdf

California Department of Water Resources [CDWR]. 2016. Drought and Water Year 2016: Hot and Dry Conditions Continue. 2016 California Drought Update.

California Natural Resources Agency [CNRA]. 2016. Safeguarding California: Implementation Action Plan. California Natural Resources Agency.
http://resources.ca.gov/docs/climate/safeguarding/Safeguarding%20California-Implementation%20Action%20Plans.pdf

California Secretary of State [CSOS]. 2016. Proposition 64 Marijuana Legalization Initiative Statute, Analysis by the Legislative Analyst.

California Water Commission [CWC]. 2019. Proposition 1 Water Storage Investment Program: Funding the Public Benefits of Water Storage Projects. Website accessed April 5, 2019 at https://cwc.ca.gov/Water-Storage

Carah, J.K., J.K. Howard, S.E. Thompson, A.G. Short Gianotti, S.D. Bauer, S.M. Carlson, D.N. Dralle, M.W. Gabriel, L.L. Hulette, B.J. Johnson, C.A. Knight, S.J. Kupferberg, S.L. Martin, R.L. Naylor, and M.E. Power. 2015. High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization. BioScience 65(8):822-829. DOI: 10.1093/biosci/biv083

Case, M.J., J.J. Lawler, and J.A. Tomasevic. 2015. Relative Sensitivity to Climate Change of Species in Northwestern North America. Biological Conservation 187:127-133.

Catenazzi, A., and S.J. Kupferberg. 2013. The Importance of Thermal Conditions to Recruitment Success in Stream-Breeding Frog Populations Distributed Across a Productivity Gradient. Biological Conservation 168:40-48.

Catenazzi, A., and S.J. Kupferberg. 2017. Variation in Thermal Niche of a Declining River-breeding Frog: From Counter-Gradient Responses to Population Distribution Patterns. Freshwater Biology 62:1255-1265.

Catenazzi, A., and S.J. Kupferberg. 2018. Consequences of Dam-Altered Thermal Regimes for a Riverine Herbivore's Digestive Efficiency, Growth and Vulnerability to Predation. Freshwater Biology 63(9):1037-1048. DOI: 10.1111/fwb.13112

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent Changes Towards Earlier Springs: Early Signs of Climate Warming in Western North America? Watershed Management Council Networker (Spring):3-7.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate Change Scenarios for the California Region. Climatic Change 87 (Supplement 1):21-42. DOI: 10.1007/s10584-007-9377-6

Climate Change Science Program [CCSP]. 2008. Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. *In* T.R. Karl, G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (Editors). Department of Commerce, NOAA's National Climate Data Center, Washington, DC.

Conlon, J.M., A. Sonnevend, M. Patel, C. Davidson, P.F. Nielsen, T. Pál, and L.A. Rollins-Smith. 2003. Isolation of Peptides of the Brevinin-1 Family with Potent Candidacidal Activity from the Skin Secretions of the Frog *Rana boylii*. The Journal of Peptide Research 62:207-213.

Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains. Science Advances 1(1):e1400082. DOI: 10.1126/sciadv.1400082

Cook, D.G., S. White, and P. White. 2012. *Rana boylii* (Foothill Yellow-legged Frog) Upland Movement. Herpetological Review 43(2):325-326.

Cordone, A.J., and D.W. Kelley. 1961. The Influence of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game 47(2):189-228.

Crayon, J.J. 1998. *Rana catesbeiana* (Bullfrog). Diet. Herpetological Review 29(4):232.

Davidson, C. 2004. Declining Downwind: Amphibian Population Declines in California and Historical Pesticide Use. Ecological Applications 14(6):1892-1902.

Davidson, C., H.B. Shaffer, and M.R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B, and Climate-Change Hypotheses for California Amphibian Declines. Conservation Biology 16(6):1588-1601.

Davidson, C., M.F. Benard, H.B. Shaffer, J.M. Parker, C. O'Leary, J.M. Conlon, and L.A. Rollins-Smith. 2007. Effects of Chytrid and Carbaryl Exposure on Survival, Growth and Skin Peptide Defenses in Foothill Yellow-legged Frogs. Environmental Science and Technology 41(5):1771-1776. DOI: 10.1021/es0611947

Dawson, T.P., S.T. Jackson, J.I. House, I.C. Prentice, and G.M. Mace. 2011. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science 332:53-58.

Dettinger, M., H. Alpert, J. Battles, J. Kusel, H. Safford, D. Fougeres, C. Knight, L. Miller, and S. Sawyer. 2018. Sierra Nevada Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004.

Dever, J.A. 2007. Fine-scale Genetic Structure in the Threatened Foothill Yellow-legged Frog (*Rana boylii*). Journal of Herpetology 41(1):168-173.

Dillingham, C.P., C.W. Koppl, J.E. Drennan, S.J. Kupferberg, A.J. Lind, C.S. Silver, T.V. Hopkins, K.D. Wiseman, and K.R. Marlow. 2018. *In Situ* Population Enhancement of an At-Risk Population of Foothill Yellow-legged Frogs, *Rana boylii*, in the North Fork Feather River, Butte County, California. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Doubledee, R.A., E.B. Muller, and R.M. Nisbet. 2003. Bullfrogs, Disturbance Regimes, and the Persistence of California Red-legged Frogs. Journal of Wildlife Management 67(2):424-438.

Drennan, J.E., K.A. Marlow, K.D. Wiseman, R.E. Jackman, I.A. Chan, and J.L. Lessard. 2015. *Rana boylii* Aging: A Growing Concern. Abstract of paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 8-10 January 2015, Malibu, CA.

Drost, C.A., and G.M. Fellers. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. Conservation Biology 10(2):414-425.

East Contra Costa County Habitat Conservancy [ECCCHC]. 2018. East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan Annual Report 2017.

Ecoclub Amphibian Group, K.L. Pope, G.M. Wengert, J.E. Foley, D.T. Ashton, and R.G. Botzler. 2016. Citizen Scientists Monitor a Deadly Fungus Threatening Amphibian Communities in Northern Coastal California, USA. Journal of Wildlife Diseases 52(3):516-523.

El Dorado Irrigation District [EID]. 2007. Project 184 Foothill Yellow-legged Frog Monitoring Plan.

Electric Consumers Protection Act [ECPA]. 1986. 16 United States Code § 797, 803.

Eriksson A., F. Elías-Wolff, B. Mehlig, and A. Manica. 2014. The Emergence of the Rescue Effect from Explicit Within- and Between-Patch Dynamics in a Metapopulation. Proceedings of the Royal Society B 281:20133127. http://dx.doi.org/10.1098/rspb.2013.3127

Evenden, F.G., Jr. 1948. Food Habitats of *Triturus granulosus* in Western Oregon. Copeia 1948(3):219-220.

Fahrig, L., and G. Merriam. 1985. Habitat Patch Connectivity and Population Survival. Ecology 66(6):1762-1768.

Federal Energy Regulatory Commission [FERC]. 2007a. Order Issuing New License, Project No. 233-081.

Federal Energy Regulatory Commission [FERC]. 2007b. Relicensing Settlement Agreement for the Upper American River Project and Chili Bar Hydroelectric Project.

Federal Energy Regulatory Commission [FERC]. 2009a. Order Amending Forest Service 4(e) Condition 5A, Project No. 1962-187.

Federal Energy Regulatory Commission [FERC]. 2009b. Order Issuing New License, Project No. 2130-033.

Federal Energy Regulatory Commission [FERC]. 2014. Order Issuing New License, Project No. 2101-084.

Federal Energy Regulatory Commission [FERC]. 2018. Final Environmental Impact Statement. Lassen Lodge Hydroelectric Project. Project No. 12496-002.

Federal Energy Regulatory Commission [FERC]. 2019. Active Licenses. FERC eLibrary. Accessed March 10, 2019. https://www.ferc.gov/industries/hydropower/gen-info/licensing/active-licenses.xls

Fellers, G.M. 2005. *Rana boylii* Baird, 1854(b). Pp. 534-536 *In* M. Lannoo (Editor). Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.

Ferguson, E. 2019. Cultivating Cooperation: Pilot Study Around Headwaters of Mattole River Considers the Effect of Legal Cannabis Cultivators on Northern California Watersheds. Outdoor California 79(1):22-29.

Fidenci, P. 2006. *Rana boylii* (Foothill Yellow-legged Frog) Predation. Herpetological Review 37(2):208.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting Climate Change in California. Ecological Impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, MA, and the Ecological Society of America, Washington, DC.

Fisher, R.N., and H.B. Shaffer. 1996. The Decline of Amphibians in California's Great Central Valley. Conservation Biology 10(5):1387-1397.

Fitch, H.S. 1936. Amphibians and Reptiles of the Rogue River Basin, Oregon. The American Midland Naturalist 17(3):634-652.

Fitch, H.S. 1938. *Rana boylii* in Oregon. Copeia 1938(3):148.

Fitch, H.S. 1941. The Feeding Habits of California Garter Snakes. California Fish and Game 27(2):1-32.

Florsheim, J.L., A. Chin, A.M. Kinoshita, and S. Nourbakhshbeidokhti. 2017. Effect of Storms During Drought on Post-Wildfire Recovery of Channel Sediment Dynamics and Habitat in the Southern California Chaparral, USA. Earth Surface Processes and Landforms 42(1):1482-1492. DOI: 10.1002/esp.4117.

Foe, C.G., and B. Croyle. 1998. Mercury Concentration and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary. Staff report, California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone Hazards to Amphibians and Reptiles. Herpetological Review 25(4):150-153, 156.

Fox, W. 1952. Notes on the Feeding Habits of Pacific Coast Garter Snakes. Herpetologica 8(1):4-8.

Fuller, D.D., and A.J. Lind. 1992. Implications of Fish Habitat Improvement Structures for Other Stream Vertebrates. Pp. 96-104 *In* Proceedings of the Symposium on Biodiversity of Northwestern California. R. Harris and D. Erman (Editors). Santa Rosa, CA.

Fuller, T.E., K.L. Pope, D.T. Ashton, and H.H. Welsh. 2011. Linking the Distribution of an Invasive Amphibian (*Rana catesbeiana*) to Habitat Conditions in a Managed River System in Northern California. Restoration Ecology 19(201):204-213. DOI: 10.1111/j.1526-100X.2010.00708.x

Furey, P.C., S.J. Kupferberg, and A.J. Lind. 2014. The Perils of Unpalatable Periphyton: *Didymosphenia* and Other Mucilaginous Stalked Diatoms as Food for Tadpoles. Diatom Research 29(3):267-280.

Gaos, A., and M. Bogan. 2001. A Direct Observation Survey of the Lower Rubicon River. California Department of Fish and Game, Rancho Cordova, CA.

Garcia and Associates [GANDA]. 2008. Identifying Microclimatic and Water Flow Triggers Associated with Breeding Activities of a Foothill Yellow-Legged Frog (*Rana boylii*) Population on the North Fork Feather River, California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-041.

Garcia and Associates [GANDA]. 2017. 2016 Surveys for Foothill Yellow-legged Frog El Dorado County, California for the El Dorado Hydroelectric Project (FERC No. 184) – Job 642-9. Prepared for El Dorado Irrigation District, San Francisco, CA.

Garcia and Associates [GANDA]. 2018. Draft Results of 2017 Surveys for Foothill Yellow-legged Frog (*Rana boylii*) on the Cresta and Poe Reaches of the North Fork Feather River – Job 708/145. Prepared for Pacific Gas and Electric Company, San Francisco, CA.

Geisseler, D., and W.R. Horwath. 2016. Grapevine Production in California. A collaboration between the California Department of Food and Agriculture; Fertilization Education and Research, Project; and University of California, Davis.
https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Grapevine_Production_CA.pdf

Gibbs, J.P., and A.R. Breisch. 2001. Climate Warming and Calling Phenology of Frogs Near Ithaca, New York, 1900-1999. Conservation Biology 15(4):1175-1178.

Gomulkiewicz, R., and R.D. Holt. 1995. When Does Evolution by Natural Selection Prevent Extinction? Evolution 49(1):201-207.

Gonsolin, T.T. 2010. Ecology of Foothill Yellow-legged Frogs in Upper Coyote Creek, Santa Clara County, CA. Master's Thesis. San Jose State University, San Jose, CA.

Grantham, T. E., A. M. Merenlender, and V. H. Resh. 2010. Climatic Influences and Anthropogenic Stressors: An Integrated Framework for Stream Flow Management in Mediterranean-climate California, U.S.A. Freshwater Biology 55(Supplement 1):188-204. DOI: 10.1111/j.1365-2427.2009.02379.x

Green, D.M. 1986a. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Karyological Evidence. Systematic Zoology 35(3):273-282.

Green, D.M. 1986b. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Electrophoretic Evidence. Systematic Zoology 35(3):283-296.

Green Diamond Resource Company [GDRC]. 2018. Mad River Foothill Yellow-legged Frog Egg Mass Surveys Summary Humboldt County, California. Progress report to the California Department of Fish and Wildlife, Wildlife Branch-Nongame Wildlife Program, pursuant to the requirements of Scientific Collecting Permit Entity #6348.

Griffin, D., and K.J. Anchukaitis. 2014. How Unusual is the 2012-2014 California Drought? Geophysical Research Letters 41: 9017-9023. DOI: 10.1002/2014GL062433.

Grinnell, J., and T. I. Storer. 1924. Animal Life in the Yosemite: An Account of the Mammals, Birds, Reptiles, and Amphibians in a Cross-section of the Sierra Nevada. University of California Press, Berkeley, CA.

Grinnell, J., J. Dixon, and J.M. Linsdale. 1930. Vertebrate Natural History of a Section of Northern California Through the Lassen Peak Region. University of California Press, Berkeley, CA.

Haggarty, M. 2006. Habitat Differentiation and Resource Use Among Different Age Classes of Post Metamorphic *Rana boylii* on Red Bank Creek, Tehama County, California. Master's Thesis. Humboldt State University, Arcata, CA.

Harvey, B.C., and T.E. Lisle. 1998. Effects of Suction Dredging on Streams: A Review and an Evaluation Strategy. Fisheries 23(8):8-17.

Hayes, M.P., and M.R. Jennings. 1986. Decline of Ranid Frog Species in Western North America: Are Bullfrogs (*Rana catesbeiana*) Responsible? Journal of Herpetology 20(4):490-509.

Hayes, M.P., and M.R. Jennings. 1988. Habitat Correlates of Distribution of the California Red-legged Frog (*Rana aurora draytonii*) and the Foothill Yellow-Legged Frog (*Rana boylii*): Implications for Management. Pp. 144-158 *In* Management of Amphibians, Reptiles, and Small Mammals in North America, General Technical Report. RM-166 R.C. Szaro, K.E. Severson, and D.R. Patton (Technical Coordinators). USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hayes, M.P., C.A. Wheeler, A.J. Lind, G.A. Green, and D.C. Macfarlane (Technical Coordinators). 2016. Foothill Yellow-Legged Frog Conservation Assessment in California. Gen. Tech. Rep. PSW-GTR-248. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffle, and A. Vonk. 2003. Atrazine-induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence. Environmental Health Perspectives 11(4):568-575.

Hayes, T.B., P. Case, S. Chui, D. Chung, C. Haeffele, K. Haston, M. Lee, V. P. Mai, Y. Marjuoa, J. Parker, and M. Tsui. 2006. Pesticide Mixtures, Endocrine Disruption, and Amphibian Declines: Are We Underestimating the Impact? Environmental Health Perspectives 114(Supplement 1):40-50.

Hemphill, D.V. 1952. The Vertebrate Fauna of the Boreal Areas of the Southern Yolla Bolly Mountains, California. PhD Dissertation. Oregon State University, Corvallis.

Hillis, D.M., and T.P. Wilcox. 2005. Phylogeny of the New World true frogs (*Rana*). Molecular Phylogenetics and Evolution 34:299-314.

Hoffmann, A.A., and C.M. Sgrò. 2011. Climate Change and Evolutionary Adaptation. Nature 470:479-485. https://www.nature.com/articles/nature09670

Hogan, S., and C. Zuber. 2012. North Fork American River 2012 Summary Report. California Department of Fish and Wildlife Heritage and Wild Trout Program, Rancho Cordova, CA.

Hopkins, G.R., S.S. French, and E.D. Brodie. 2013. Increased Frequency and Severity of Developmental Deformities in Rough-skinned Newt (*Taricha granulosa*) Embryos Exposed to Road Deicing Salts (NaCl & $MgCl_2$). Environmental Pollution 173:264-269. http://dx.doi.org/10.1016/j.envpol.2012.10.002

Hothem, R.L., A.M. Meckstroth, K.E. Wegner, M.R. Jennings, and J.J. Crayon. 2009. Diets of Three Species of Anurans from the Cache Creek Watershed, California, USA. Journal of Herpetology 43(2):275-283.

Hothem, R.L., M.R. Jennings, and J.J. Crayon. 2010. Mercury Contamination in Three Species of Anuran Amphibians from the Cache Creek Watershed, California, USA. Environmental Monitoring and Assessment 163:433-448. https://doi.org/10.1007/s10661-009-0847-3

Humboldt Redwoods Company [HRC]. 2015. Habitat Conservation Plan for the Properties of The Pacific Lumber Company, Scotia Pacific Holding Company, and Salmon Creek Corporation under the Ownership and Management of Humboldt Redwood Company, LLC, as of July 2008. Established February 1999, Revised 12 August 2015.

ICF International. 2012. Final Santa Clara Valley Habitat Plan. https://scv-habitatagency.org/178/Santa-Clara-Valley-Habitat-Plan

Jackman, R.E., J.E. Drennan, K.R. Marlow, and K.D. Wiseman. 2004. Some Effects of Spring and Summer Pulse Flows on River-breeding Foothill Yellow-legged Frogs (*Rana boylii*) along the North Fork Feather

River. Abstract of paper presented at the Cal-Neva and Humboldt Chapters of the American Fisheries Society Annual Meeting 23 April 2004, Redding, CA.

Jennings, M.R., and M.P. Hayes. 1985. Pre-1900 Overharvest of California Red-Legged Frogs (*Rana aurora draytonii*): The Inducement for Bullfrog (*Rana catesbeiana*) Introduction. Herpetologica 41(1):94-103.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Contract No. 8023. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA.

Jennings, M.R., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Coloration. Herpetological Review 36(4):438.

Jones & Stokes Associates. 2006. East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan.

Karraker, N.E., J.P. Gibbs, and J.R. Vonesh. 2008. Impacts of Road Deicing Salt on the Demography of Vernal Pool-breeding Amphibians. Ecological Applications 18(3):724-734.

Kats, L.B., and R.P. Ferrer. 2003. Alien Predators and Amphibian Declines: Review of Two Decades of Science and the Transition to Conservation. Diversity and Distributions 9(2):99-110.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streambank Management Implications…A review. Journal of Range Management 37(5):430-437.

Kauffman, J.B., W.C. Krueger, and M. Varva. 1983. Impacts of Cattle on Streambanks in Northeastern Oregon. Journal of Range Management 36(6):683-685.

Keeley, J.E. 2005. Fire History of the San Francisco East Bay Region and Implications for Landscape Patterns. International Journal of Wildland Fire 14:285-296.

Keeley, J.E., and A.D. Syphard. 2016. Climate Change and Future Fire Regimes: Examples from California. Geosciences 6(7):37. DOI: 10.3390/geosciences6030037

Kerby, J.L., and A. Sih. 2015. Effects of Carbaryl on Species Interactions of the Foothill Yellow Legged Frog (*Rana boylii*) and the Pacific Treefrog (*Pseudacris regilla*). Hydrobiologia 746(1):255-269. DOI: 10.1007/s10750-014-2137-5

Kiesecker, J.M. 2002. Synergism Between Trematode Infection and Pesticide Exposure: A Link to Amphibian Limb Deformities in Nature? PNAS 99(15):9900-9904. https://doi.org/10.1073/pnas.152098899

Kiesecker, J.M., and A.R. Blaustein. 1997. Influences of Egg Laying Behavior on Pathogenic Infection of Amphibian Eggs. Conservation Biology 11(1):214-220.

Knowles, N., M.D. Dettinger, and D.R. Cayan. 2006. Trends in Snowfall Versus Rainfall in the Western United States. Journal of Climate 19(18):4545-4559. https://doi.org/10.1175/JCLI3850.1

Kupferberg, S.J. 1996a. Hydrologic and Geomorphic Factors Affecting Conservation of a River-Breeding Frog (*Rana boylii*). Ecological Applications 6(4):1322-1344.

Kupferberg, S.J. 1996b. The Ecology of Native Tadpoles (*Rana boylii* and *Hyla regilla*) and the Impact of Invading Bullfrogs (*Rana catesbeiana*) in a Northern California River. PhD Dissertation. University of California, Berkeley.

Kupferberg, S.J. 1997a. Bullfrog (*Rana catesbeiana*) Invasion of a California River: The Role of Larval Competition. Ecology 78(6):1736-1751.

Kupferberg, S.J. 1997b. The Role of Larval Diet in Anuran Metamorphosis. American Zoology 37:146-159.

Kupferberg, S., and A. Catenazzi. 2019. Between Bedrock and a Hard Place: Riverine Frogs Navigate Tradeoffs of Pool Permanency and Disease Risk During Drought. Abstract prepared for the Joint Meeting of Ichthyologists and Herpetologists. 24-28 July 2019, Snowbird, UT.

Kupferberg, S.J., A. Catenazzi, K. Lunde, A. Lind, and W. Palen. 2009a. Parasitic Copepod (*Lernaea cyprinacea*) Outbreaks in Foothill Yellow-legged Frogs (*Rana boylii*) Linked to Unusually Warm Summers and Amphibian Malformations in Northern California. Copeia 2009(3):529-537.

Kupferberg, S.J., A. Catenazzi, and M.E. Power. 2011a. The Importance of Water Temperature and Algal Assemblage for Frog Conservation in Northern California Rivers with Hydroelectric Projects. Final Report to the California Energy Commission, PIER. CEC-500-2014-033.

Kupferberg, S.J., and P.C. Furey. 2015. An Independent Impact Analysis using Carnegie State Vehicular Recreation Area Habitat Monitoring System Data. Friends of Tesla Park Technical Memorandum. DOI: 10.13140/RG.2.1.4898.9207

Kupferberg, S.J., A. Lind, J. Mount, and S. Yarnell. 2009b. Pulsed Flow Effects on the Foothill Yellow-Legged Frog (*Rana boylii*): Integration of Empirical, Experimental, and Hydrodynamic Modeling Approaches. Final Report. California Energy Commission, PIER. CEC-500-2009-002.

Kupferberg, S.J, A.J. Lind, and W.J. Palen. 2009c. Pulsed Flow Effects on the Foothill Yellow-legged Frog (*Rana boylii*): Population Modeling. Final Report to the California Energy Commission, PIER. CEC-500-2009-002a.

Kupferberg, S.J., A.J. Lind, V. Thill, and S.M. Yarnell. 2011b. Water Velocity Tolerance in Tadpoles of the Foothill Yellow-legged Frog (*Rana boylii*): Swimming Performance, Growth, and Survival. Copeia 2011(1):141-152.

Kupferberg, S.J., W.J. Palen, A.J. Lind, S. Bobzien, A. Catenazzi, J. Drennan, and M.E. Power. 2012. Effects of Flow Regimes Altered by Dams on Survival, Population Declines, and Range-wide Losses of California River-Breeding Frogs. Conservation Biology 26(3):513-524.

Lambert, M.R., T. Tran, A. Kilian, T. Ezaz, and D.K. Skelly. 2019. Molecular Evidence for Sex Reversal in Wild populations of Green Frogs (*Rana clamitans*). PeerJ 7:e6449. DOI: 10.7717/peerj.6449

Lande, R., and S. Shannon. 1996. The Role of Genetic Variation in Adaptation and Population Persistence in a Changing Environment. Evolution 50(1):434-437.

Leidy, R.A., E. Gonsolin, and G.A. Leidy. 2009. Late-summer Aggregation of the Foothill Yellow-legged Frog (*Rana boylii*) in Central California. The Southwestern Naturalist 54(3):367-368.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, and J.N. Seiber. 1999. Summertime Transport of Current-Use Pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. Environmental Toxicology and Chemistry 18(12):2715-2722.

Lind, A.J. 2005. Reintroduction of a Declining Amphibian: Determining an Ecologically Feasible Approach for the Foothill Yellow-legged Frog (*Rana boylii*) Through Analysis of Decline Factors, Genetic Structure, and Habitat Associations. PhD Dissertation. University of California, Davis.

Lind, A.J., J.B. Bettaso, and S.M. Yarnell. 2003a. Natural History Notes: *Rana boylii* (Foothill Yellow-legged Frog) and *Rana catesbeiana* (Bullfrog). Reproductive behavior. Herpetological Review 34(3):234-235.

Lind, A.J., L. Conway, H. (Eddinger) Sanders, P. Strand, and T. Tharalson. 2003b. Distribution, Relative Abundance, and Habitat of Foothill Yellow-legged Frogs (*Rana boylii*) on National Forests in the Southern Sierra Nevada Mountains of California. Report to the FHR Program of Region 5 of the USDA Forest Service.

Lind, A.J., P.Q. Spinks, G.M. Fellers, and H.B. Shaffer. 2011. Rangewide Phylogeography and Landscape Genetics of the Western U.S. Endemic Frog *Rana boylii* (Ranidae): Implications for the Conservation of Frogs and Rivers. Conservation Genetics 12:269-284.

Lind, A.J., and H.H. Welsh, Jr. 1994. Ontogenetic Changes in Foraging Behaviour and Habitat Use by the Oregon Garter Snake, *Thamnophis atratus hydrophilus*. Animal Behaviour 48:1261-1273.

Lind, A.J., H.H. Welsh, Jr., and C.A. Wheeler. 2016. Foothill Yellow-legged Frog (*Rana boylii*) Oviposition Site Choice at Multiple Spatial Scales. Journal of Herpetology 50(2):263-270.

Lind, A.J., H.H. Welsh, Jr., and R.A. Wilson. 1996. The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii*) in Northwestern California. Herpetological Review 27(2):62-67.

Little, E.E., and R.D. Calfee. 2000. The Effects of UVB Radiation on the Toxicity of Fire-Fighting Chemicals. Final Report. U.S. Geological Service, Columbia Environmental Research Center, Columbia, MO.

Loomis, R.B. 1965. The Yellow-legged Frog, *Rana boylei*, from the Sierra San Pedro Mártir, Baja California Norte, México. Herpetologica 21(1):78-80.

Lowe, J. 2009. Amphibian Chytrid (*Batrachochytrium dendrobatidis*) in Postmetamorphic *Rana boylii* in Inner Coast Ranges of Central California. Herpetological Review 40(2):180.

Macey, R.J., J.L. Strasburg, J.A. Brisson, V.T. Vredenburg, M. Jennings, and A. Larson. 2001. Molecular Phylogenetics of Western North American Frogs of the *Rana boylii* Species Group. Molecular Phylogenetics and Evolution 19(1):131-143.

MacTague, L., and P.T. Northen. 1993. Underwater Vocalization by the Foothill Yellow-Legged Frog (*Rana boylii*). Transactions of the Western Section of the Wildlife Society 29:1-7.

Mallakpour, I., M. Sadegh, and A. AghaKouchak. 2018. A New Normal for Streamflow in California in a Warming Climate: Wetter Wet Seasons and Drier Dry Seasons. Journal of Hydrology 567:203-211.

Mallery, M. 2010. Marijuana National Forest: Encroachment on California Public Lands for Cannabis Cultivation. Berkeley Undergrad Journal 23(2):1-50. http://escholarship.org/uc/item/7r10t66s#page-2

Marlow, C.B., and T.M. Pogacnik. 1985. Time of Grazing and Cattle-Induced Damage to Streambanks. Pp. 279-284 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Marlow, K.R., K.D. Wiseman, C.A. Wheeler, J.E. Drennan, and R.E. Jackman. 2016. Identification of Individual Foothill Yellow-legged Frogs (*Rana boylii*) using Chin Pattern Photographs: A Non-Invasive and Effective Method for Small Population Studies. Herpetological Review 47(2):193-198.

Martin, C. 1940. A New Snake and Two Frogs for Yosemite National Park. Yosemite Nature Notes 19(11):83-85.

Martin, P.L., R.E. Goodhue, and B.D. Wright. 2018. Introduction. Pp. 1-25 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California.
https://s.giannini.ucop.edu/uploads/giannini_public/07/5c/075c8120-3705-4a79-ae74-130fdfe46c6b/introduction.pdf

McCartney-Melstad, E., M. Gidiş, and H.B. Shaffer. 2018. Population Genomic Data Reveal Extreme Geographic Subdivision and Novel Conservation Actions for the Declining Foothill Yellow-legged Frog. Heredity 121:112-125.

Megahan, W.F., J.G. King, and K.A. Seyedbagheri. 1995. Hydrologic and Erosional Responses of a Granitic Watershed to Helicopter Logging and Broadcast Burning. Forest Science 41(4):777-795.

Merenlender, A.M. 2000. Mapping Vineyard Expansion Provides Information on Agriculture and the Environment. California Agriculture 54(3):7-12.

Mierau, D.W., W.J. Trush, G.J. Rossi, J.K. Carah, M.O. Clifford, and J.K. Howard. 2017. Managing Diversions in Unregulated Streams using a Modified Percent-of-Flow Approach. Freshwater Biology 63:752-768. DOI: 10.1111/fwb.12985

Moyle, P.B. 1973. Effects of Introduced Bullfrogs, *Rana catesbeiana*, on the Native Frogs of the San Joaquin Valley, California. Copeia 1973(1):18-22.

Moyle, P.B., and P.J. Randall. 1998. Evaluating the Biotic Integrity of Watersheds in the Sierra Nevada, California. Conservation Biology 12(6):1318-1326.

Napa County. 2010. Napa County Voluntary Oak Woodlands Management Plan.

National Integrated Drought Information System [NIDIS]. 2019. Drought in California from 2000-2019. National Drought Mitigation Center, U.S. Department of Agriculture Federal Drought Assistance. Accessed 25 April 2019 at https://www.drought.gov/drought/states/california

National Marine Fisheries Service [NMFS]. 2012. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office, Sacramento, CA.

National Marine Fisheries Service [NMFS]. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, CA.

Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians & Reptiles of the Pacific Northwest. University Press of Idaho, Moscow, ID.

Off-Highway Motor Vehicle Recreation Commission [OHMVRC]. 2017. Off-Highway Motor Vehicle Recreation Commission Program Report, January 2017. http://ohv.parks.ca.gov/pages/1140/files/OHMVR-Commission-2017-Program_Report-FINAL-Mar2017_web.pdf

Office of Environmental Health Hazard Assessment [OEHAA], California Environmental Protection Agency. 2018. Indicators of Climate Change in California. https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

Olson, D.H., and R. Davis. 2009. Conservation Assessment for the Foothill Yellow-legged Frog (*Rana boylii*) in Oregon. USDA Forest Service Region 6 and USDI Bureau of Land Management Interagency Special Status Species Program.

Olson, E.O., J.D. Shedd, and T.N. Engstrom. 2016. A Field Inventory and Collections Summary of Herpetofauna from the Sutter Buttes, an "Inland Island" within California's Great Central Valley. Western North American Naturalist 76(3):352-366.

Pacific Gas and Electric [PG&E]. 2018. Pit 3, 4, and 5 Hydroelectric Project (FERC Project No. 233) Foothill Yellow-Legged Frog Monitoring 2017 Annual Report.

Padgett-Flohr, G.E., and R.L. Hopkins. 2009. *Batrachochytrium dendrobatidis*, a Novel Pathogen Approaching Endemism in Central California. Diseases of Aquatic Organisms 83:1-9.

Palstra, F.P., and D.E. Ruzzante. 2008. Genetic Estimates of Contemporary Effective Population Size: What Can They Tell Us about the Importance of Genetic Stochasticity for Wild Population Persistence? Molecular Ecology 17:3428-3447. DOI: 10.1111/j.1365-294X.2008.03842.x

Paoletti, D.J., D.H. Olson, and A.R. Blaustein. 2011. Responses of Foothill Yellow-legged Frog (*Rana boylii*) Larvae to an Introduced Predator. Copeia 2011(1):161-168.

Parks, S.A., C. Miller, J.T. Abatzoglou, L.M. Holsinger, M-A. Parisien, and S.Z. Dobrowski. 2016. How Will Climate Change Affect Wildland Fire Severity in the Western US? Environmental Research Letters 11:035002. DOI: 10.1088/1748-9326/11/3/035002

Parmesan, C., and G. Yohe. 2003. A Globally Coherent Fingerprint of Climate Change Impacts across Natural Systems. Nature 421(6918):37-42. DOI: 10.1038/nature01286

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs Call at a Higher Pitch in Traffic Noise. Ecology and Society 12(1):25. http://www.ecologyandsociety.org/vol14/iss1/art25/

Peek, R.A. 2011. Landscape Genetics of Foothill Yellow-legged Frogs (*Rana boylii*) in Regulated and Unregulated Rivers: Assessing Connectivity and Genetic Fragmentation. Master's Thesis. University of San Francisco, San Francisco, CA.

Peek, R.A. 2018. Population Genetics of a Sentinel Stream-breeding Frog (*Rana boylii*). PhD Dissertation. University of California, Davis.

Peek, R., and S. Kupferberg. 2016. Assessing the Need for Endangered Species Act Protection of the Foothill Yellow-legged Frog (*Rana boylii*): What do Breeding Censuses Indicate? Abstract of poster presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 7-8 January 2016, Davis, CA.

Pilliod, D.S., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and Amphibians in North America. Forest Ecology and Management 178:163-181.

Placer County Water Agency [PCWA]. 2008. Final AQ 12 – Special-Status Amphibian and Aquatic Reptile Technical Study Report – 2007. Placer County Water Agency Middle Fork American River Project (FERC No. 2079), Auburn, CA.

Pounds, A., A.C.O.Q. Carnaval, and S. Corn. 2007. Climate Change, Biodiversity Loss, and Amphibian Declines. Pp. 19-20 *In* C. Gascon, J.P. Collins, R.D. Moore, D.R. Church, J.E. McKay, and J.R. Mendelson III (Editors). IUCN Amphibian Conservation Action Plan, Proceedings: IUCN/SSC Amphibian Conservation Summit 2005.

Powell, R., R. Conant, and J.T. Collins. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central America, Fourth Edition.

Power, M.E., M.S. Parker, and W.E. Dietrich. 2008. Seasonal Reassembly of a River Food Web: Floods, Droughts, and Impacts of Fish. Ecological Monographs 78(2):263-282.

Prado, M. 2005. Rare Frogs Put at Risk by Visitors in West Marin. Marin Independent Journal. Newspaper article, May 09, 2005.

Public Policy Institute of California [PPIC]. 2018. Storing Water. https://www.ppic.org/publication/californias-water-storing-water/

Public Policy Institute of California [PPIC]. 2019. California's Future: Population. https://www.ppic.org/wp-content/uploads/californias-future-population-january-2019.pdf

Radeloff, V.C., D.P. Helmers, H.A. Kramer, M.H. Mockrin, P.M. Alexandre, A. Bar-Massada, V. Butsic, T.J. Hawbaker, S. Martinuzzi, A.D. Syphard, and S.I. Stewart. 2018. Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk. PNAS 115(13):3314-3319. https://doi.org/10.1073/pnas.1718850115

Railsback, S.F., B.C. Harvey, S.J. Kupferberg, M.M. Lang, S. McBain, and H.H. Welsh, Jr. 2016. Modeling Potential River Management Conflicts between Frogs and Salmonids. Canadian Journal of Fisheries and Aquatic Sciences 73:773-784.

Reeder, N.M.M., A.P. Pessier, and V.T. Vredenburg. 2012. A Reservoir Species for the Emerging Amphibian Pathogen *Batrachochytrium dendrobatidis* Thrives in a Landscape Decimated by Disease. PLoS ONE 7(3):e33567. https://doi.org/10.1371/journal.pone.0033567

Riegel, J.A. 1959. The Systematics and Distribution of Crayfishes in California. California Fish and Game 45:29-50.

Relyea, R.A. 2005. The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Ecological Applications 15(2):618-627.

Relyea, R.A., and N. Diecks. 2008. An Unforeseen Chain of Events: Lethal Effects of Pesticides on Frogs at Sublethal Concentrations. Ecological Applications 18(7):1728-1742.

Rombough, C. 2006. Winter Habitat Use by Juvenile Foothill Yellow-legged Frogs (*Rana boylii*): The Importance of Seeps. *In* Abstracts from the 2006 Annual Meetings of the Society for Northwestern Vertebrate Biology and the Washington Chapter of the Wildlife Society. Northwest Naturalist 87(2):159.

Rombough, C.J., J. Chastain, A.M. Schwab, and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(4):438-439.

Rombough, C.J., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation: Eggs and Hatchlings. Herpetological Review 36(2):163-164.

Rombough, C.J., and M.P. Hayes. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Reproduction. Herpetological Review 38(1):70-71.

Russell, K.R., D.H. Van Lear, and D.C. Guynn, Jr. 1999. Prescribed Fire Effects on Herpetofauna: Review and Management Implications. Wildlife Society Bulletin 27(2):374-384.

San Joaquin Council of Governments, Inc. [SJCOG 2018]. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2018 Annual Report.

San Joaquin County. 2000. San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan.

Santa Clara Valley Habitat Agency [SCVHA]. 2019. Santa Clara Valley Habitat Plan 4th Annual Report FY2017-2018.

Scheele, B.C., F. Pasmans, L.F. Skerratt, L. Berger, A. Martel, W. Beukema, A.A. Acevedo, P.A. Burrows, T. Carvalhos, A. Catenazzi, I. De la Riva, M.C. Fisher, S.V. Flechas, C.N. Foster, P. Frías-Álvarez, T.W.J. Garner, B. Gratwicke, J.M. Guayasamin, M. Hirschfeld, J.E. Kolby, T.A. Kosch, E. La Marca, D.B. Lindenmayer, K.R. Lips, A.V. Longo, R. Maneyro, C.A. McDonald, J. Mendelson III, P. Palacios-Rodriguez, G. Parra-Olea, C.L. Richards-Zawacki, M-O. Rödel, S.M. Rovito, C. Soto-Azat, L.F. Toledo, J. Voyles, C. Weldon, S.M. Whitfield, M. Wilkinson, K.R. Zamudio, and S. Canessa. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. Science 363(6434):1459-1463. DOI: 10.1126/science.aav0379

Siekert, R.E., Q.D. Skinner, M.A. Smith, J.L. Dodd, and J.D. Rogers. 1985. Channel Response of an Ephemeral Stream in Wyoming to Selected Grazing Treatments. Pp. 276-278 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Silver, C.S. 2017. Population-level Variation in Vocalizations of *Rana boylii*, the Foothill Yellow-legged Frog. Master's Thesis. California State University, Chico, Chico, CA.

Snover, M.L., and M.J. Adams. 2016. Herpetological Monitoring and Assessment on the Trinity River, Trinity County, California-Final Report: U.S. Geological Survey Open-File Report 2016-1089. http://dx.doi.org/10.3133/ofr20161089

Sparling, D.W., and G.M. Fellers. 2007. Comparative Toxicity of Chlorpyrifos, Diazinon, Malathion and Their Oxon Derivatives to *Rana boylii*. Environmental Pollution 147:535-539.

Sparling, D.W., and G.M. Fellers. 2009. Toxicity of Two Insecticides to California, USA, Anurans and Its Relevance to Declining Amphibian Populations. Environmental Toxicology and Chemistry 28(8):1696-1703.

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and Amphibian Declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.

Spencer, C.N., and F.R. Hauer. 1991. Phosphorus and Nitrogen Dynamics in Streams During a Wildfire. Journal of the North American Benthological Society 10(1):24-30.

Spring Rivers Ecological Sciences. 2003. Foothill Yellow-legged Frog (*Rana boylii*) Studies in 2002 for Pacific Gas and Electric Company's Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233). Pacific Gas and Electric Company, Technical and Ecological Services, San Ramon, CA.

State Board of Forestry and Fire Protection [SBFFP]. 2018. 2018 Strategic Fire Plan for California. Accessed March 1, 2019 at: http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf1614.pdf

State Water Resources Control Board [SWRCB]. 2017. Water Quality Certification for the Pacific Gas and Electric Company Poe Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2107.

State Water Resources Control Board [SWRCB]. 2018. Water Quality Certification for the South Feather Water and Power Agency South Feather Power Project, Federal Energy Regulatory Commission Project No. 2088.

State Water Resources Control Board [SWRCB]. 2019. February 2019 Executive Director's Report. Accessed February 18, 2019 at:
https://www.waterboards.ca.gov/board_info/exec_dir_rpts/2019/ed_rpt_021119.pdf

Stebbins, R.C. 2003. Peterson Filed Guides Western Reptiles and Amphibians. Third Edition. Houghton Mifflin Company, Boston, MA.

Stebbins, R.C., and S.M. McGinnis. 2012. Field Guide to Amphibians and Reptiles of California. Revised Edition. University of California Press, Berkeley, CA.

Stephens, S.L., N. Burrows, A. Buyantuyev, R.W. Gray, R.E. Keane, R. Kubian, S. Liu, F. Seijo, L. Shu, K.G. Tolhurst, and J.W. van Wagtendonk. 2014. Temperate and Boreal Forest Mega-Fires: Characteristics and Challenges. Frontiers in Ecology and the Environment 12(2):115-122.

Stephens, S.L, J.D. McIver, R.E.J. Boerner, C.J. Fettig, J.B. Fontaine, B.R. Hartsough, P.I. Kennedy, and D.W. Schwilk. 2012. The Effects of Forest Fuel-Reduction Treatments in the United States. BioScience 62(6):549-560.

Stewart, I.T. 2009. Changes in Snowpack and Snowmelt Runoff for Key Mountain Regions. Hydrological Processes 23:78-94. DOI: 10.1002/hyp.7128

Stillwater Sciences. 2012. Analysis of Long-term River Regulation Effects on Genetic Connectivity of Foothill Yellow-legged Frogs (*Rana boylii*) in the Alameda Creek Watershed. Final Report. Prepared by Stillwater Sciences, Berkeley, CA for SFPUC, San Francisco, CA.

Stopper, G.F., L. Hecker, R.A. Franssen, and S.K. Sessions. 2002. How Trematodes Cause Limb Deformities in Amphibians. Journal of Experimental Zoology Part B (Molecular and Developmental Evolution) 294:252-263.

Storer, T.I. 1923. Coastal Range of Yellow-legged Frog in California. Copeia 114:8.

Storer, T.I. 1925. A Synopsis of the Amphibia of California. University of California Publication Zoology 27:1-342.

Sweet, S.S. 1983. Mechanics of a Natural Extinction Event: *Rana boylii* in Southern California. Abstract of paper presented at the Joint Annual Meeting of the Herpetologists' League and Society for the Study of Amphibians and Reptiles 7-12 August 1983, Salt Lake City, UT.

Syphard, A.D., V.C. Radeloff, T.J. Hawbaker, and S.I. Stewart. 2009. Conservation Threats Due to Human-Caused Increases in Fire Frequency in Mediterranean-Climate Ecosystems. Conservation Biology 23(3):758–769. DOI: 10.1111/j.1523-1739.2009.01223.x

Syphard, A.D., V.C. Radeloff, J.E. Keeley, T.J. Hawbaker, M.K. Clayton, S.I. Stewart, and R.B. Hammer. 2007. Human Influence on California Fire Regimes. Ecological Applications 17(5):1388-1402.

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573.

Thompson, C., R. Sweitzer, M. Gabriel, K. Purcell, R. Barrett, and R. Poppenga. 2014. Impacts of Rodenticide and Insecticide Toxicants from Marijuana Cultivation Sites on Fisher Survival Rates in the Sierra National Forest, California. Conservation Letters 7(2):91-102.

Thomson, R.C., A.N. Wright, and H.B. Shaffer. 2016. California Amphibian and Reptile Species of Special Concern. University of California Press, Berkeley, CA.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

Tracey, J.A., C.J. Rochester, S.A. Hathaway, K.L. Preston, A.D. Syphard, A.G. Vandergast, J.E. Diffendorfer, J. Franklin, J.B. MacKenzie, T.A. Oberbauer, S. Tremor, C.S. Winchell, and R.N. Fisher. 2018. Prioritizing Conserved Areas Threatened by Wildfire and Fragmentation for Monitoring and Management. PLoS ONE 13(9):e0200203. https://doi.org/10.1371/journal.pone.0200203

Troïanowski, M., N. Mondy, A. Dumet, C. Arcajo, and T. Lengagne. 2017. Effects of Traffic Noise on Tree Frog Stress Levels, Immunity, and Color Signaling. Conservation Biology 31(5):1132-1140.

Twitty, V.C., D. Grant, and O. Anderson. 1967. Amphibian Orientation: An Unexpected Observation. Science 155(3760):352-353.

Unrine, J.M., C.H. Jagoe, W.A. Hopkins, and H.A. Brant. 2004. Adverse Effects of Ecologically Relevant Dietary Mercury Exposure in Southern Leopard Frog (*Rana sphenocephala*) Larvae. Environmental Toxicology and Chemistry 23(12):2964-2970.

U.S. Fish and Wildlife Service [USFWS]. 1998. Recovery Plan for the Shasta Crayfish (*Pacifastacus fortis*). U.S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service [USFWS]. 2015. Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions. Federal Register 80(126):37568-37579.

U.S. Fish and Wildlife Service [USFWS] and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report. U.S. Fish and Wildlife Service, Arcata, CA.

U.S. Forest Service [USFS]. 2004. Sierra Nevada Forest Plan Amendment. Final Supplemental Environmental Impact Statement, Record of Decision.

U.S. Forest Service [USFS] and Bureau of Land Management [BLM]. 1994. Standards and guidelines for management of habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl.

Van Wagner, T.J. 1996. Selected Life-History and Ecological Aspects of a Population of Foothill Yellow-legged Frogs (*Rana boylii*) from Clear Creek, Nevada County, California. Master's Thesis. California State University Chico, Chico, CA.

Volpe, R.J., III, R. Green, D. Heien, and R. Howitt. 2010. Wine-Grape Production Trends Reflect Evolving Consumer Demand over 30 Years. California Agriculture 64(1):42-46.

Wang, I.J., J.C. Brenner, and V. Bustic. 2017. Cannabis, an Emerging Agricultural Crop, Leads to Deforestation and Fragmentation. Frontiers in Ecology and the Environment 15(9):495-501. DOI: 10.1002/fee.1634

Warren, D.L., A.N. Wright, S.N. Seifert, and H.B. Shaffer. 2014. Incorporating Model Complexity and Spatial Sampling Bias into Ecological Niche Models of Climate Change Risks Faced by 90 California Vertebrate Species of Concern. Diversity and Distributions 20:334-343. DOI: 10.1111/ddi.12160

Welsh, H.H., Jr., and G.R. Hodgson. 2011. Spatial Relationships in a Dendritic Network: The Herpetofaunal Metacommunity of the Mattole River Catchment of Northwest California. Ecography 34:49-66. DOI: 10.1111/j.1600-0587.2010.06123.x

Welsh, H.H., Jr., G.R. Hodgson, and A.J. Lind. 2005. Ecography of the Herpetofauna of a Northern California Watershed: Linking Species Patterson to Landscape Processes. Ecography 23:521-536.

Welsh, H.H., Jr., and L.M. Ollivier. 1998. Stream Amphibians as Indicators of Ecosystem Stress: A Case Study from California's Redwoods. Ecological Applications 8(4):1118-1132.

Werschkul, D.F., and M.T. Christensen. 1977. Differential Predation by *Lepomis macrochirus* on the Eggs and Tadpoles of *Rana*. Herpetologica 33(2):237-241.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Science 313(5789):940-943. DOI: 10.1126/science.1128834

Wheeler, C.A., J.B. Bettaso, D.T. Ashton and H.H. Welsh, Jr. 2014. Effects of Water Temperature on Breeding Phenology, Growth, and Metamorphosis of Foothill Yellow-legged Frogs (*Rana boylii*): A Case Study of the Regulated Mainstem and Unregulated Tributaries of California's Trinity River. River Research and Applications 31:1276-1286. DOI: 10.1002/rra.2820

Wheeler, C.A., J.M. Garwood, and H.H. Welsh, Jr. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Physiological Skin Color Transformation. Herpetological Review 36(2):164-165.

Wheeler, C.A., A.J. Lind, H.H. Welsh, Jr., and A.K. Cummings. 2018. Factors that Influence the Timing of Calling and Oviposition of a Lotic Frog in Northwestern California. Journal of Herpetology 52(3):289-298.

Wheeler, C.A., and H.H. Welsh, Jr. 2008. Mating Strategy and Breeding Patterns of the Foothill Yellow-legged Frog (*Rana boylii*). Herpetological Conservation and Biology 3(2):128-142.

Wheeler, C.A., H.H. Welsh, Jr., and T. Roelofs. 2006. Oviposition Site Selection, Movement, and Spatial Ecology of the Foothill Yellow-legged Frog (*Rana boylii*). Final Report to the California Department of Fish and Game Contract No. P0385106, Sacramento, CA.

Williams, A.P., R. Seager, J.T. Abatzoglou, B.I. Cook, J.E. Smerdon, and E.R. Cook. 2015. Contribution of Anthropogenic Warming to California Drought During 2012–2014. Geophysical Research Letters 42:6819-6828. DOI: 10.1002/2015GL064924

Williams S.E., L.P. Shoo, J.L. Isaac, A.A. Hoffmann, and G. Langham. 2008. Towards an Integrated Framework for Assessing the Vulnerability of Species to Climate Change. PLoS Biol 6(12):e325. DOI: 10.1371/journal.pbio.0060325

Wiseman, K.D., and J. Bettaso. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Cannibalism and Predation. Herpetological Review 38(2):193.

Wiseman, K.D., K.R. Marlow, R.E. Jackman, and J.E. Drennan. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(2):162-163.

Wright, A.N., R.J. Hijmans, M.W. Schwartz, and H.B. Shaffer. 2013. California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change. Final Report to the California Department of Fish and Wildlife. Contract No. P0685904, Sacramento, CA.

Yap, T.A., M.S. Koo, R.F. Ambrose, and V.T. Vredenburg. 2018. Introduced Bullfrog Facilitates Pathogen Invasion in the Western United States. PLoS ONE 13(4):e0188384. https://doi.org/10.1371/journal.pone.0188384

Yarnell, S.M. 2005. Spatial Heterogeneity of *Rana boylii* Habitat: Physical Properties, Quantification and Ecological Meaningfulness. PhD Dissertation. University of California, Davis.

Yarnell, S.M., J.H. Viers, and J.F. Mount. 2010. Ecology and Management of the Spring Snowmelt Recession. Bioscience 60(2):114-127.

Yoon, J-H., S-Y.S. Wang, R.R. Gillies, B. Kravitz, L. Hipps, and P.J. Rasch. 2015. Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle under Global Warming. Nature Communications 6:8657. DOI: 10.1038/ncomms9657

Young, C.A., M. Escobar, M. Fernandes, B. Joyce, M. Kiparsky, J.F. Mount, V. Mehta, J.H. Viers, and D. Yates. 2009. Modeling the Hydrology of California's Sierra Nevada for Sub-Watershed Scale Adaptation to Climate Change. Journal of American Water Resources Association 45:1409-1423.

Zhang, H., C. Cai, W. Fang, J. Wang, Y. Zhang, J. Liu, and X. Jia. 2013. Oxidative Damage and Apoptosis Induced by Microcystin-LR in the Liver of *Rana nigromaculata* in Vivo. Aquatic Toxicology 140-141:11-18.

Zillioux, E.J., D.B. Porcella, and J.M. Benoit. 1993. Mercury Cycling and Effects in Freshwater Wetland Ecosystems. Environmental Toxicology and Chemistry 12:2245-2264.

Zweifel, R.G. 1955. Ecology, Distribution, and Systematics of Frogs of the *Rana boylei* Group. University of California Publications in Zoology 54(4):207-292.

Zweifel, R.G. 1968. *Rana boylii* Baird, Foothill Yellow-legged Frog. Catalogue of American Amphibians and Reptiles. Pp. 71.1-71.2.

Personal Communications

Alvarez, J. 2017. The Wildlife Project. Email to the Department.

Alvarez, J. 2018. The Wildlife Project. Letter to Tom Eakin, Peter Michael Winery, provided to the Department.

Anderson, D.G. 2017. Redwood National Park. Foothill Yellow-legged Frog (*Rana boylii*) Survey of Redwood Creek on August 28, 2017, Mainstem Redwood Creek, Redwood National Park, Humboldt County, California.

Ashton, D. 2017. U.S. Geological Survey. Email response to Department solicitation for information.

Blanchard, K. 2018. California Department of Fish and Wildlife. Email response to Department solicitation for information.

Bourque, R. 2018. California Department of Fish and Wildlife. Email.

Bourque, R. 2019. California Department of Fish and Wildlife. Internal review comments.

Chinnichi, S. 2017. Humboldt Redwood Company. Email response to the Department solicitation for information.

Grefsrud, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Hamm, K. 2017. Green Diamond Resource Company. Email response to the Department solicitation for information.

Kundargi, K., 2014. California Department of Fish and Wildlife. Internal memo.

Kupferberg, S. 2018. UC Berkeley. Spreadsheet of Eel River egg mass survey results.

Kupferberg, S. 2019. UC Berkeley. Spreadsheet of breeding censuses and clutch density plots by river.

Kupferberg, S., and A. Lind. 2017. UC Berkeley and U.S. Forest Service. Draft recommendation for best management practices to the Department's North Central Region.

Kupferberg, S., and R. Peek. 2018. UC Davis and UC Berkeley. Email to the Department.

Kupferberg, S., R. Peek, and A. Catenazzi. 2015. UC Berkeley, UC Davis, and Southern Illinois University Carbondale. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., and M. Power. 2015. UC Berkeley. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., M. van Hattem, and W. Stokes. 2017. UC Berkeley and California Department of Fish and Wildlife. Email about lower flows in the South Fork Eel River and upstream cannabis.

Rose, T. 2014. Wildlife Photographer. Photographs of river otters consuming Foothill Yellow-legged Frogs on the Eel River.

Smith, J. 2015. San Jose State University. Frog and Turtle Studies on Upper Coyote Creek for (2010-2015; cumulative report).

Smith, J. 2016. San Jose State University. Upper Coyote Creek Stream Survey Report – 20 April 2016.

Smith, J. 2017. San Jose State University. Upper Llagas Creek Fish Resources in Response to the Recent Drought, Fire, and Extreme Wet Winter, 8 October 2017.

Sweet, S. 2017. University of California Santa Barbara. Email to the Department.

van Hattem, M. 2018. California Department of Fish and Wildlife. Telephone call.

van Hattem, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Weiss, K. 2018. California Department of Fish and Wildlife. Email.

Geographic Information System Data Sources

Amphibian and Reptile Species of Special Concern [ARSSC]. 2012. Museum Dataset.

Biological Information Observation System [BIOS]. Aquatic Organisms [ds193]; Aquatic Ecotoxicology - Whiskeytown NRA 2002-2003 [ds199]; North American Herpetological Education and Research Project (HERP) - Gov [ds1127]; and Electric Power Plants - California Energy Commission [ds2650].

California Department of Fish and Wildlife [CDFW]. Various Unpublished Foothill Yellow-legged Frog Observations from 2009 through 2018.

California Department of Food and Agriculture [CDFA]. Temporary Licenses Issued for Commercial Cannabis Cultivation, January 2019 version.

California Department of Forestry [CAL FIRE]. 2017 Fire Perimeters and 2018 Supplement.

California Department of Water Resources [DWR]. 2000. Dams under the Jurisdiction of the Division of Safety and Dams.

California Military Department [CMD]. Camp Roberts Boundary.

California Natural Diversity Database [CNDDB]. February 2019 version.

California Protected Areas Database [CPAD]. Public Lands, 2017 version.

California Wildlife Habitat Relationships [CWHR]. 2014 Range Map Modified to Include the Sutter Buttes.

Electronic Water Rights Information Management System [eWRIMS]. Points of Diversion - State Water Resources Control Board, 2019 version.

Facility Registry Service [FRS]. Power Plants Operated by the Army Corps of Engineers – U.S. Environmental Protection Agency Facility Registry Service, 2014 version.

Humboldt Redwood Company [HRC]. Incidental Foothill Yellow-legged Frog Observations from 1995 to 2018.

Mendocino Redwoods Company [MRC]. Foothill Yellow-legged Frog Egg Mass Survey Results from 2017 and 2018.

National Hydrography Dataset [NHD]. Watershed Boundary Dataset, 2018 version.

PRISM Climate Group [PRISM]. Annual Average Precipitation for 2012 through 2016; and the 30 Year Average from 1980-2010.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

U.S. Bureau of Land Management [BLM]. Tribal Lands - Bureau of Indian Affairs Surface Management, 2014 version.

U.S. Department of Defense [DOD]. Military Lands Boundaries in California.

Patterson, Laura@Wildlife

From: Lind, Amy -FS <amy.lind@usda.gov>
Sent: Wednesday, June 12, 2019 11:08 AM
To: Patterson, Laura@Wildlife
Subject: RE: Peer Review Request: Foothill Yellow-legged Frog Status Review
Attachments: DRAFT FYLF Status Review-2019.05.21_Lind.docx

Laura – I have gotten through a bit of the document and am now out of the office until July 1. I have included my comments as 'track changes' text edits, or margin notes, through page 35, in the attached WORD document. I was unable to just pick and choose sections to read (lost the thread too much), so I did start at the beginning and work forward.

If you would like my comments on the remainder of the document, I may be to work on it again in early July. Let me know.

Overall, I found this to be a comprehensive document on the status of the foothill yellow-legged frog (*Rana boylii*) in California. It is well written with clear logic. The incorporation of new genetic data is a big positive!

A couple of "housekeeping" items:

- Recommend number the Sections/Subsections for ease of referencing and so the reader can better follow the different heading levels (e.g., 1.0, 1.1, 1.1.1, 1.1.2, etc.)
- Check the use of present and past tense throughout the document – I noted a few places where things seems off.
- Figures:
  - For figures taken from other sources, remove the original figure number and legend, describe the figure in your own words in this document's caption, and cite appropriately (e.g., your Figures 2 and 4)
  - Also, some figures are in the figure list, and included in the text, but never referenced in the text.
  - Consider adding more references to figures (you can point to them more than once if they are relevant) – as they say "a picture is worth 1000 words" ☺

I apologize that I was unable to complete the full review on your requested timeline. My upcoming time off has been planned for months.
Best Regards,
Amy

Amy Lind
Hydroelectric Coordinator
Forest Service
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amy.lind@usda.gov
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Nevada City, CA 95959
www.fs.fed.us
Caring for the land and serving people

Please note my new email, and update your address books.

From: Patterson, Laura@Wildlife [mailto:Laura.Patterson@wildlife.ca.gov]
Sent: Tuesday, May 21, 2019 2:37 PM
To: Lind, Amy -FS <amy.lind@usda.gov>
Subject: RE: Peer Review Request: Foothill Yellow-legged Frog Status Review

Okay, thanks. The letter gives some instruction on what to focus on, but here's how I'd prioritize your review by the major headings in the TOC:

1. Factors Affecting Ability to Survive and Reproduce
2. Status and Trends in California
3. Existing Management
4. Management Recommendations
5. Biology and Ecology
6. Protection Afforded by Listing
7. Summary of Listing Factors
8. Listing Recommendation

If you have very limited time, please try to get through 1, 2, 7 and 8. You can completely ignore the Regulatory Setting and Economic Considerations.

Thanks so much!

From: Lind, Amy -FS <amy.lind@usda.gov>
Sent: Tuesday, May 21, 2019 2:04 PM
To: Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov>
Subject: RE: Peer Review Request: Foothill Yellow-legged Frog Status Review

Laura – I have received the review documents. I will make every effort to meet your deadline, though as I noted previously, a good portion of the review period coincides with previously scheduled out of town travel. I will update you as the requested deadline approaches.
Best,
Amy

Amy Lind
Hydroelectric Coordinator
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Caring for the land and serving people

Please note my new email, and update your address books.

From: Patterson, Laura@Wildlife [mailto:Laura.Patterson@wildlife.ca.gov]
Sent: Tuesday, May 21, 2019 1:55 PM
To: Lind, Amy -FS <amy.lind@usda.gov>
Subject: RE: Peer Review Request: Foothill Yellow-legged Frog Status Review

Good afternoon, Dr. Lind,

Thanks for your patience. We had a couple of loose ends to tie up. Please see the attached letter and draft status review. If you have any questions or concerns with the timeline, please let me know.

Will you please respond to this email to confirm you received it?

Thanks again,
Laura

From: Lind, Amy -FS <alind@fs.fed.us>
Sent: Tuesday, April 9, 2019 2:22 PM
To: Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov>
Subject: RE: Peer Review Request: Foothill Yellow-legged Frog Status Review

Laura – Sorry for the delayed reply. I am happy to respond positively to your request for a peer review of the California status review for the foothill yellow-legged frog and I look forward to seeing the draft document.

My only constraint is timing. I will be out of town during a portion of the proposed review period. I will do my best to respond by mid-June (as described in your email) and I will certainly update you if I need a few more days.

Thank you for including me in this process,
Amy

Amy Lind
Hydroelectric Coordinator

Forest Service
Tahoe and Plumas National Forests

p: 530-478-6298
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Caring for the land and serving people

Please note my new email, and update your address books.

From: Patterson, Laura@Wildlife [mailto:Laura.Patterson@wildlife.ca.gov]
Sent: Tuesday, April 2, 2019 3:25 PM
To: Lind, Amy -FS <alind@fs.fed.us>
Subject: Peer Review Request: Foothill Yellow-legged Frog Status Review

Dear Dr. Lind,

The Fish and Game Commission (Commission) was petitioned to list the Foothill Yellow-legged Frog as threatened under the California Endangered Species Act (CESA) by the Center for Biological Diversity in December 2016. The California Department of Fish and Wildlife (Department) is tasked with writing a status review and providing a recommendation to the Commission on whether or not the best scientific information available supports the petitioner's position that listing is warranted. Part of the status review process is external peer review of the draft status review.

I am contacting you as a Foothill Yellow-legged Frog subject matter expert to request your participation in the peer review process. The Department expects the draft will be ready on for distribution to peer reviewers on or around May 17th. We would ask that you focus your review on the scientific information available regarding the status of Foothill Yellow-legged Frogs in California. Your peer review of the science and analysis regarding each of the listing factors prescribed in CESA (i.e., present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) is particularly valuable. We request that comments be submitted on or before one month from the date of receipt (on or around June 17th).

In addition, per the Department's Peer Review Policy (Department Bulletin 2017-03), I must ensure that you have no financial or other conflict of interest with the outcome or implications of the peer reviewed product.

Please respond to whether you are willing and able to participate in this important part of the listing determination process by Thursday April 11th.

Thank you for your consideration,
Laura

Laura Patterson
Statewide Amphibian and Reptile Conservation Coordinator
California Department of Fish and Wildlife
Nongame Wildlife Program
1812 9th Street
Sacramento, CA 95811
Please Help Endangered Species at Tax Time
https://www.wildlife.ca.gov/Tax-Donation

STATE OF CALIFORNIA
NATURAL RESOURCES AGENCY
DEPARTMENT OF FISH AND WILDLIFE

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF THE **FOOTHILL YELLOW-LEGGED FROG** (*Rana boylii*) IN CALIFORNIA

CHARLTON H. BONHAM, DIRECTOR
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
External Peer Review Draft

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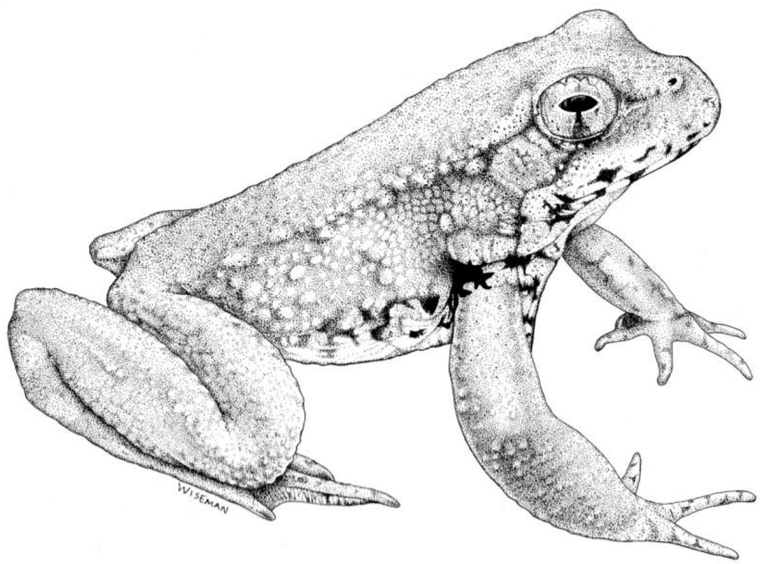

ACKNOWLEDGMENTS

Laura Patterson prepared this report. Stephanie Hogan, Madeleine Wieland, and Margaret Mantor assisted with portions of the report, including the sections on Status and Trends in California and Existing Management. Kristi Cripe provided GIS analysis and figures. Review of a draft document was provided by the following California Department of Fish and Wildlife (Department) staff: Ryan Bourque, Marcia Grefsrud, and Mike van Hattem.

The Department is extremely grateful for the valuable comments provided on this report by the following peer reviewers: Dr. Sarah Kupferberg, Dr. Amy Lind, Dr. Jimmy McGuire, and Dr. Ryan Peek. The conclusions in this report are those of the Department and do not necessarily reflect those of the reviewers.

Cover photograph by Isaac Chellman, used with permission.

Illustration by Kevin Wiseman, used with permission.

EXECUTIVE SUMMARY

[To be completed after external peer review]

REGULATORY SETTING

Petition Evaluation Process

A petition to list the Foothill Yellow-legged Frog (*Rana boylii*) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on December 14, 2016 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on December 22, 2016 and published a formal notice of receipt of the petition on January 20, 2017 (Cal. Reg. Notice Register 2017, No. 3-Z, p. 46). A petition to list or delist a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3).

On April 17, 2017, the Department provided the Commission with its evaluation of the petition, "Evaluation of the Petition from the Center For Biological Diversity to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on June 21, 2017, in Smith River, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Foothill Yellow-legged Frog was designated a candidate species on July 7, 2017 (Cal. Reg. Notice Register 2017, No. 27-Z, p. 986).

Status Review Overview

The Commission's action designating the Foothill Yellow-legged Frog as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 21, 2018, in Sacramento, California, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

This status review report is not intended to be an exhaustive review of all published scientific literature relevant to the Foothill Yellow-legged Frog; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to the Foothill Yellow-legged Frog. This review is intended to provide the Commission with the most current information on the Foothill Yellow-legged Frog and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The status review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

Federal Endangered Species Act Review

The Foothill Yellow-legged Frog is currently under review for possible listing as threatened or endangered under the federal Endangered Species Act (ESA) in response to a July 11, 2012 petition submitted by the Center for Biological Diversity. On July 1, 2015, the U.S. Fish and Wildlife Service (USFWS) published its 90-day finding that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted and initiated a status review of the species (USFWS 2015). On March 16, 2016, the Center for Biological Diversity sued the USFWS to compel issuance of a 12-month finding on whether listing under the ESA is warranted. On August 30, 2016, the parties reached a stipulated settlement agreement that the USFWS shall publish its 12-month finding in the Federal Register on or before September 30, 2020 (*Center for Biological Diversity v. S.M.R. Jewell* (D.D.C. Aug. 30, 2016, No. 16-CV-00503)).

BIOLOGY AND ECOLOGY

Species Description and Life History

> *"In its life-history* boylii *exhibits several striking specializations which are in all probability related to the requirements of life of a stream-dwelling species"* – Tracy I. Storer, 1925

The Foothill Yellow-legged Frog is a small- to medium-sized frog; adults range from 38 to 81 mm (1.5-3.2 in) snout to urostyle length (SUL) with females attaining a larger size than males and males possessing paired internal vocal sacs (Zweifel 1955, Nussbaum et al. 1983, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs are typically gray, brown, olive, or reddish with brown-black flecking and mottling, which generally matches the substrate of the stream in which they reside (Nussbaum et al. 1983, Stebbins and McGinnis 2012). They often have a pale triangle between the eyes and snout and broad dark bars on the hind legs (Zweifel 1955, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs have a relatively squat body and granular skin, giving them a rough appearance similar to a toad, and fully webbed feet with slightly expanded toe tips (Nussbaum et al. 1983). The tympanum is also rough

and relatively small compared to congeners at around one-half the diameter of the eye (Zweifel 1955). The dorsolateral folds (glandular ridges extending from the eye area to the rump) in Foothill Yellow-legged Frogs are indistinct compared to other western North American ranids (Stebbins and McGinnis 2012). Ventrally, the abdomen is white with variable amounts of dark mottling on the chest and throat, which are unique enough to be used to identify individuals (Marlow et al. 2016). As their name suggests, the underside of their hind limbs and lower abdomen are often yellow; however, individuals with orange and red have been observed within the range of the California Red-legged Frog (*Rana draytonii*), making hindlimb coloration a poor diagnostic characteristic for this species (Jennings and Hayes 2005).

Adult females likely lay one clutch of eggs per year and may breed every year (Storer 1925, Wheeler et al. 2006). Foothill Yellow-legged Frog egg masses resemble a compact cluster of grapes approximately 45 to 90 mm (1.8-3.5 in) in diameter length-wise and contain anywhere from around 100 to over 3,000 eggs (Kupferberg et al. 2009c, Hayes et al. 2016). The individual embryos are dark brown to black with a lighter area at the vegetative pole and surrounded by three jelly envelopes that range in diameter from approximately 3.9 to 6.0 mm (0.15-0.25 in) (Storer 1925, Zweifel 1955, Hayes et al. 2016).

Foothill Yellow-legged Frog tadpoles hatch out around 7.5 mm (0.3 in) long and are a dark brown or black (Storer 1925, Zweifel 1955). They grow rapidly to 37 to 56 mm (1.5-2.2 in) and turn olive with a coarse brown mottling above and an opaque silvery color below (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012). Their eyes are positioned dorsally when viewed from above (i.e., within the outline of the head), and their mouths are large, downward-oriented, and suction-like with several tooth rows (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012, Hayes et al. 2016). Foothill Yellow-legged Frogs metamorphose at around 14-17 mm (0.55-0.67 in) SUL (Fellers 2005). Sexual maturity is attained at around 30-40 mm (1.2-1.6 in) SUL and 1 year for males and around 40-50 mm (1.6-2.0 in) SUL and 3 years for females, although in some populations this has been accelerated by a year (Zweifel 1955, Kupferberg et al. 2009c, Breedveld and Ellis 2018). During the breeding season, males can be distinguished from females by the presence of nuptial pads (swollen darkened thumb bases that aid in holding females during amplexus) and calling, which frequently occurs underwater but sometimes from the surface (MacTague and Northen 1993, Stebbins 2003, Silver 2017).

The reported lifespan of Foothill Yellow-legged Frogs varies widely by study. Storer (1925) and Van Wagner (1996) estimated a maximum age of 2 years for both sexes and the vast majority of the population. Breedveld and Ellis (2018) calculated the typical lifespan of males at 3-4 years and 5-6 years for females. Bourque (2008), using skeletochronology, found an individual over 7 years old and a mean age of 4.7 and 3.6 years for males and females, respectively. Drennan et al. (2015) estimated maximum age at 13 years for both sexes in a Sierra Nevada population and 12 for males and 11 for females in a Coast Range population.

Commented [USFS_AJL1]: Check this reference again. Is this correct? It is hard to imagine anyone thinking they only lived two years.

Range and Distribution

Foothill Yellow-legged Frogs historically ranged from the Willamette River drainage in Oregon west of the Sierra-Cascade crest to at least the San Gabriel River drainage in Los Angeles County, California (Figure 1; Zweifel 1955, Stebbins 2003). In addition, a disjunct population was reported from 2,040 m

Figure 1. Foothill Yellow-legged Frog historical range (adapted from CWHR, Loomis [1965], Nussbaum et al. [1983])

(6,700 ft) in the Sierra San Pedro Mártir, Baja California Norte, México (Loomis 1965). In California, the species occupies foothill and mountain streams in the Klamath, Cascade, Sutter Buttes, Coast, Sierra Nevada, and Transverse ranges from sea level to 1,940 m (6,400 ft), but generally below 1,525 m (5,000 ft) (Hemphill 1952, Nussbaum et al. 1983, Stebbins 2003, Olson et al. 2016). Zweifel (1955) considered Foothill Yellow-legged Frogs to be present and abundant throughout their range where streams possessed suitable habitat.

Taxonomy and Phylogeny

Foothill Yellow-legged Frogs belong to the family Ranidae (true frogs), which inhabits every continent except Antarctica and contains more than 700 species (Stebbins 2003). The species was first described by Baird (1854) as *Rana boylii*. After substantial taxonomic uncertainty with respect to its relationship to other ranids (frogs in the family Ranidae) and several name changes over the next century, the Foothill Yellow-legged Frog (*R. boylii* with no subspecific epithet) was eventually recognized as a distinct species again by Zweifel (1955, 1968). The phylogenetic relationships among the western North American *Rana* spp. have been revised several times and are still not entirely resolved (Thomson et al. 2016). The Foothill Yellow-legged Frog was previously thought to be most closely related to the higher elevation Mountain Yellow-legged Frog (*R. muscosa*) (Zweifel 1955; Green 1986a,b). However, genetic analyses undertaken by Macey et al. (2001) and Hillis and Wilcox (2005) suggest they are more closely related to Oregon Spotted Frogs (*R. pretiosa*) and Columbia Spotted Frogs (*R. luteiventris*), respectively.

Population Structure and Genetic Diversity

Foothill Yellow-legged Frog populations exhibit varying levels of partitioning and genetic diversity at different spatial scales. At the coarse landscape level across the species' extant range, McCartney-Melstad et al. (2018) recovered five deeply divergent, geographically cohesive, genetic clades (Figure 2), while Peek (2018) recovered six (Figure 3). Genetic divergence is the process of speciation; it is a measure of the number of mutations accumulated by populations over time from a shared ancestor that differentiate them from the other populations in a species. When genetic divergence among clades is large enough, it can be used as a tool to define new species or subspecies.

The geographic breaks among the five clades were similar between the studies, but Peek (2018) identified a separate deeply divergent genetic clade in the Feather River watershed that is distinct from the rest of the northern Sierra Nevada clade. The five clades the two studies shared include the following [Note: naming conventions follow McCartney-Melstad et al. (2018) and Peek (2018)]:

(1) Northwest/North Coast: north of San Francisco Bay in the Coast Ranges and east into Tehama County;
(2) Northeast/Northern Sierra: northern El Dorado County (North Fork American River watershed, includes Middle Fork) and north in the Sierra Nevada to southern Plumas County (Upper Yuba River watershed);

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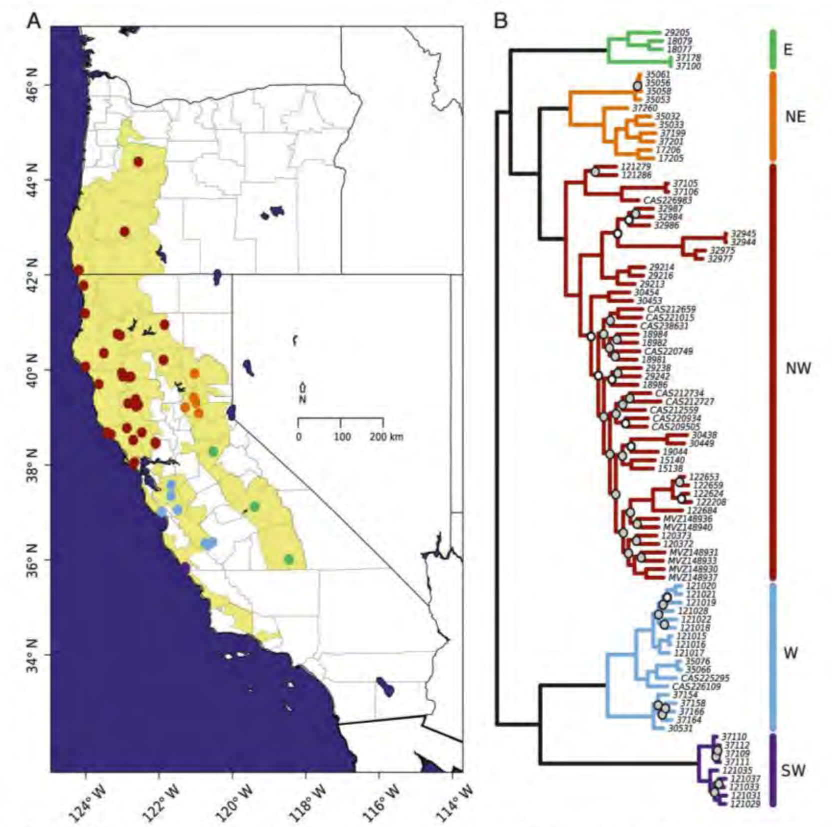

Fig. 1 **a** Map of *Rana boylii* sample localities. County outlines are shown within California and Oregon. Light yellow indicates the IUCN range map of *R. boylii*, excluding a small disjunct population at Sierra San Pedro Martir, Baja California, Mexico. Dots are colored by major grouping as determined in the **b** RAxML phylogeny, with midpoint rooting. Nodes without dots received >95% bootstrap support, those with white dots received <95% but greater than or equal to 75% bootstrap support, while nodes with gray dots received <75% bootstrap support

Figure 2. Foothill Yellow-legged Frog clades by McCartney-Melstad et al. (2018)

(3) East/Southern Sierra: El Dorado County (South Fork American River watershed) and south in the Sierra Nevada [no samples from Amador County were tested, but they would most likely fall within this clade because it is located between two other populations that occur within this clade];

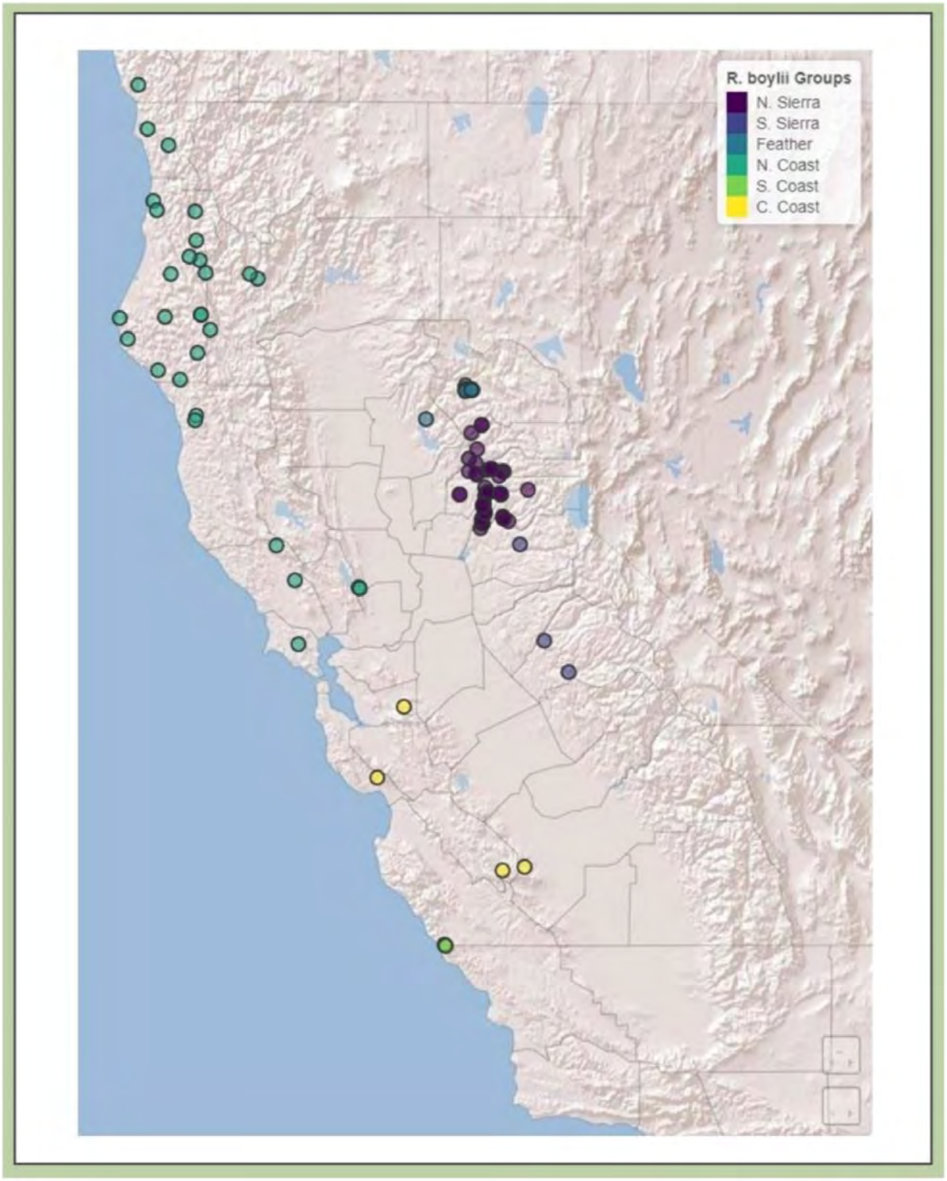

Figure 3. Foothill Yellow-legged Frog clades by Peek (2018)

(4) West/Central Coast: south of San Francisco Bay in the Coast Ranges to San Benito and Monterey counties, presumably east of the San Andreas Fault/Salinas Valley;

(5) Southwest/South Coast presumably west of the San Andreas Fault/Salinas Valley in Monterey County and south in the Coast Ranges.

The Feather River clade is found primarily in Plumas and Butte counties (Peek 2018). Peek's analysis found that this clade is as distinct as the rest of the Sierra Nevada as a cohesive group and all the coastal populations as one group, meaning it was found to be deeply divergent from the rest of the clades. McCartney-Melstad et al. (2018) also recognized the Feather River watershed as distinct from the rest of the northern Sierra but not as deeply divergent from the other clades as Peek. The Feather River watershed is also the only known location where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs (*R. sierrae*) co-occur and where two F1 hybrids (50% ancestry from each species) were found (Peek 2018). In addition, Peek's modeling results only weakly supported dividing the West/Central Coast and Southwest/South Coast groups into separate clades.

Previous work conducted by Lind et al. (2011) found a somewhat similar pattern, that populations on the periphery of the species' range are considerably genetically divergent from the rest of the range. Their results suggested that hydrologic regions and river basins were important landscape features that influenced the genetic structure of Foothill Yellow-legged Frog populations. However, using more modern genomic techniques, McCartney-Melstad et al. (2018) found nearly twice the variation among the five phylogenetic clades than among drainage basins, indicating other factors contributed to current population structure. They report that the depth of genetic divergence among Foothill Yellow-legged Frog clades exceeds that of any anuran (frog or toad) for which similar data are available and recommend using them as management units instead of the previously suggested watershed boundaries.

Levels of genetic diversity within the clades differed significantly. Genetic diversity gives species the ability to adapt to changing conditions (i.e., evolve), and its loss often signals extreme population and range reductions as well as potential inbreeding depression that can reduce survival and reproductive success (Lande and Shannon 1996, Hoffmann and Sgrò 2011, McCartney-Melstad et al. 2018). Loss of genetic diversity in Foothill Yellow-legged Frogs largely follows a north-to-south pattern with the southern clades (Southwest/South Coast and East/Southern Sierra) possessing the least amount (McCartney-Melstad et al. 2018, Peek 2018). In addition, these study results demonstrate that Foothill Yellow-legged Frogs have lost genetic diversity over time across their entire range except for the large Northwest/North Coast clade, which appears to have undergone a relatively recent population expansion (McCartney-Melstad et al. 2018, Peek 2018).

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At a watershed scale, Dever (2007) found that tributaries to rivers and streams are important for preserving genetic diversity, and populations separated by more than 10 km (6.2 mi) show signs of genetic isolation. In other words, even in the absence of anthropogenic barriers to dispersal (e.g., dams and reservoirs), individuals located more than 10 km (6.2 mi) are not typically considered part of a single interbreeding population (Olson and Davis 2009). Peek (2011, 2018) reported that at this finer-scale, population structure and genetic diversity appear to be more strongly influenced by river regulation type (i.e., dammed or undammed) than to geographic distance or watershed boundaries. In general, regulated (dammed) rivers had limited gene flow and higher genetic divergence among subpopulations compared with unregulated (undammed) rivers (Peek 2011, 2018). In addition, differences in water flow regimes within regulated rivers affected connectivity (Peek 2011, 2018). Subpopulations in hydropeaking reaches, in which pulsed flows are used for electricity generation or whitewater boating, exhibited significantly lower gene flow than those in bypass reaches where water is diverted from upstream in the basin down to power generating facilities (Figure 4; Peek 2018). River regulation had a greater influence on genetic differentiation among sites than geographic distance in the Alameda Creek watershed as well (Stillwater Sciences 2012). Reduced connectivity among sites leads to lower gene flow and a loss of genetic diversity through genetic drift, which can diminish adaptability to changing environmental conditions (Palstra and Ruzzante 2008). Peek (2011) posits that given the *R. boylii* species group is estimated to be 8 million years old (Macey et al. 2001), the significant reductions in connectivity and genetic diversity over short evolutionary time periods in regulated rivers (often less than 50 years from the time of dam construction) is cause for concern, particularly when combined with small population sizes.

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Habitat Associations and Use

> *"These frogs are so closely restricted to streams that it is unusual to find one at a greater distance from the water than it could cover in one or two leaps."* – Richard G. Zweifel, 1955

Foothill Yellow-legged Frogs inhabit rivers and streams ranging from primarily rain-fed (coastal populations) to primarily snow-influenced (most Sierra Nevada and Klamath-Cascade populations) from headwater streams to large rivers (Bury and Sisk 1997, Wheeler et al. 2014). Occupied rivers and streams flow through a variety of vegetation types including hardwood, conifer, and valley-foothill riparian forests; mixed chaparral; and wet meadows (Hayes et al. 2016). Because the species is so widespread and can be found in so many types of habitats, the vegetation community is likely less important in determining Foothill Yellow-legged Frog occupancy and abundance than the aquatic biotic and abiotic conditions in the specific river, stream, or reach (Zweifel 1955). The species is an obligate stream-breeder, which sets it apart from other western North American ranids (Wheeler et al. 2014). Foothill Yellow-legged Frog habitat is generally characterized as partly-shaded, shallow, perennial rivers and streams with a low gradient and rocky substrate that is at least cobble-sized (Zweifel 1955, Hayes and Jennings 1988). However, the use of intermittent and ephemeral streams by post-metamorphic Foothill Yellow-legged Frogs may not be all that uncommon in some parts of the species' range in California (R. Bourque pers. comm. 2019). The species has been reported from some atypical habitats as well, including ponds, isolated pools in intermittent streams, and meadows along the edge of streams that lack a rocky substrate (Fitch 1938, Zweifel 1955, J. Alvarez pers. comm. 2017, CDFW 2018a).

As stream-breeding poikilotherms (animals whose internal temperature varies with ambient temperature), appropriate flow velocity, temperature, and water availability are critically important to Foothill Yellow-legged Frogs (Kupferberg 1996a, Van Wagner 1996, Wheeler et al. 2006, Lind et al. 2016). Habitat quality is also influenced by hydrologic regime (regulated vs. unregulated), substrate, presence of non-native predators and competitors, water depth, and availability of high-quality food and basking sites (Lind et al. 1996, Yarnell 2005, Wheeler et al. 2006, Catenazzi and Kupferberg 2017). Habitat suitability and use vary by life stage, sex, geographic location, watershed size, and season and

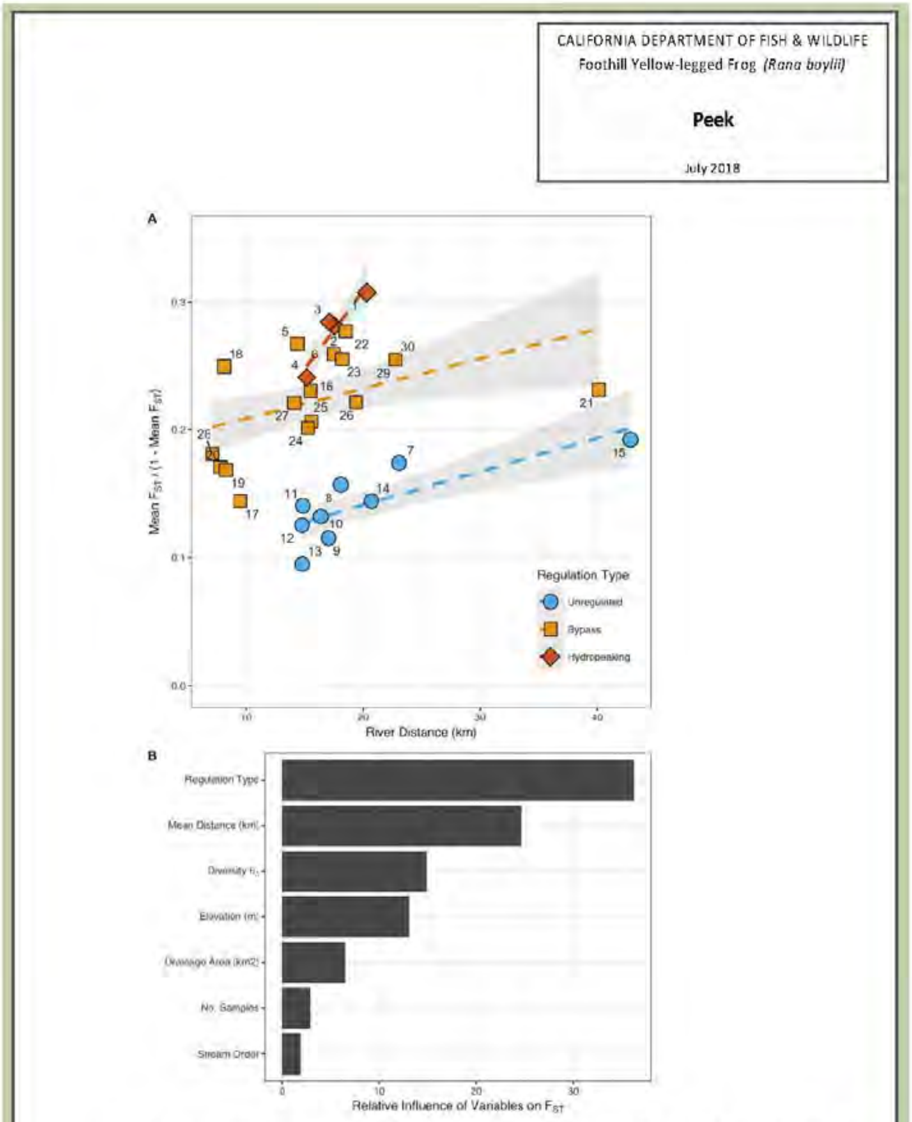

Figure 3. Relationship between river regulation and genetic differentiation in FYLF. A) Mean pairwise F_{ST} vs. mean river distance for each location; B) Relative influence of variables on F_{ST} from boosted regression tree models.

Figure 4. River regulation's relative influence on genetic differentiation from Peek (2018)

can generally be categorized as breeding and rearing habitat, nonbreeding active season habitat, and overwintering habitat (Van Wagner 1996, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011, Hayes et al. 2016, Catenazzi and Kupferberg 2017). Yarnell (2005) located higher densities of Foothill Yellow-legged Frogs in areas with greater habitat heterogeneity and suggested that they were selecting for sites that possessed the diversity of habitats necessary to support each life stage within a relatively short distance.

Breeding and Rearing Habitat

Suitable breeding habitat must be connected to suitable rearing habitat for metamorphosis to be successful. When this connectivity exists, as flows decline through the season, tadpoles can follow the receding shoreline into areas of high productivity and lower predation risk as opposed to becoming trapped in isolated pools with a high risk of overheating, desiccation, and predation (Kupferberg et al. 2009c).

Several studies on Foothill Yellow-legged Frog breeding habitat, carried out across the species' range in California, reported similar findings. Foothill Yellow-legged Frogs select oviposition (egg-laying) sites within a narrow range of depths, velocities, and substrates and exhibit fidelity to breeding sites that consistently possess suitable microhabitat characteristics over time (Kupferberg 1996a, Bondi et al. 2013, Lind et al. 2016). At a coarse-spatial scale, breeding sites in rivers and large streams are often located near the confluence of tributary streams in sunny, wide, shallow reaches (Kupferberg 1996a, Yarnell 2005, GANDA 2008, Peek 2011). These areas are highly productive compared to cooler, deeper, closed-canopy sites (Catenazzi and Kupferberg 2013). At a fine-spatial scale, females prefer to lay eggs in low velocity areas dominated by cobble- and boulder-sized substrates, often associated with sparsely-vegetated point bars (Kupferberg 1996a, Lind et al. 1996, Van Wagner 1996, Bondi et al. 2013, Lind et al. 2016). They tend to select areas with less variable, more stable flows, and in areas with higher flows at the time of oviposition, they place their eggs on the downstream side of large cobblestones and boulders, which protects them from being washed away (Kupferberg 1996a, Wheeler et al. 2006).

Appropriate rearing temperatures are vital for successful metamorphosis. Tadpoles grow faster and larger in warmer water to a point (Zweifel 1955; Catenazzi and Kupferberg 2017, 2018). Zweifel (1955) conducted experiments on embryonic thermal tolerance and determined that the critical low was approximate 6°C (43°F), and the critical high was around 26°C (79°F). Welsh and Hodgson (2011) determined that best the single variable for predicting Foothill Yellow-legged Frog presence was temperature since none were observed below 13°C (55°F), but numbers increased significantly with increasing temperature. Catenazzi and Kupferberg (2013) measured tadpole thermal preference at 16.5-22.2°C (61.7-72.0°F), and the distribution of Foothill Yellow-legged Frog populations across a watershed was consistent within this temperature range. At temperatures below 16°C (61°F), tadpoles were absent under closed canopy and scarce even with an open canopy (Ibid.). Catenazzi and Kupferberg (2017) found regional differences in apparently suitable breeding temperatures. Inland populations from primarily snowmelt-fed systems with relatively cold water were relegated to reaches that are warmer on average during the warmest 30 days of the year than coastal populations in the chiefly rainfall-fed, and thus warmer, systems (17.6-24.2°C [63.7-75.6°F] vs. 15.7-22.0°C [60.3-71.6°F], respectively).

However, experiments on tadpole thermal preference demonstrated that individuals from different source populations selected similar rearing temperatures, which presumably optimized development (Ibid.). In regulated systems, where water released from dams is often colder than normal, suitable rearing temperatures downstream may be limited (Wheeler et al. 2014, Catenazzi and Kupferberg 2017).

Appropriate flow velocities are also critical for survival to metamorphosis. The velocity at which Foothill Yellow-legged Frog egg masses shear away from the substrate they are adhered to varies according to factors such as depth and degree to which the eggs are sheltered (Spring Rivers Ecological Sciences 2003). This critical velocity is expected to decrease as the egg mass ages due to their reduced structural integrity of the protective jelly envelopes (Hayes et al. 2016). Short-duration increases in flow velocity may be tolerated if the egg masses are somewhat sheltered, but sustained high velocities increase the likelihood of detachment (Kupferberg 1996a, Spring Rivers Ecological Sciences 2003). Hatchlings and tadpoles about to undergo metamorphosis are relatively poor swimmers and require especially slow, stable flows during these stages of development (Kupferberg et al. 2011b). Tadpoles respond to increasing flows by swimming against the current to maintain position for a short period of time and eventually swimming to the bottom and seeking refuge in the rocky substrate's interstitial spaces (Ibid.). When tadpoles are exposed to repeated increases in velocities, their growth and development are delayed (Ibid.). Under experimental conditions, the critical velocity at which tadpoles were swept downstream ranged between 20 and 40 cm/s (0.66-1.31 ft/s); however, as they reach metamorphosis it decreases to as low as 10 cm/s (0.33 ft/s) (Ibid.).

Nonbreeding Active Season Habitat

Post-metamorphic Foothill Yellow-legged Frogs utilize a more diverse range of habitats and are much more dispersed during the nonbreeding active season than the breeding season. Microhabitat preferences appear to vary by location and season, but some patterns are common across the species' range. Foothill Yellow-legged Frogs tend to remain close to the water's edge (average < 3 m [10 ft]); select sunny areas with limited canopy cover; and are often associated with riffles and pools (Zweifel 1955, Hayes and Jennings 1988, Van Wagner 1996, Welsh et al. 2005, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011). Adequate water, food resources, cover from predators, ability to thermoregulate (e.g., presence of basking sites and cool refugia), and absence of non-native predators are important components of nonbreeding active season habitat (Hayes and Jennings 1988, Van Wagner 1996, Catenazzi and Kupferberg 2013).

Overwintering Habitat

Overwintering habitat varies depending on local conditions, but as with the rest of the year, Foothill Yellow-legged Frogs are most often found in or near water where they can forage and take cover from predators and high discharge events (Storer 1925, Zweifel 1955). In larger streams and rivers, Foothill Yellow-legged Frogs are often found along tributaries during the winter where the risk of being displaced by heavy flows is reduced (Kupferberg 1996a, Gonsolin 2010). Bourque (2008) found 36.4% of adult females used intermittent and ephemeral tributaries during the overwintering season. Van

Wagner (1996) located most overwintering frogs using pools with cover such as boulders, root wads, and woody debris. During high flow events, they moved to the stream's edge and took cover under vegetation like sedges (*Carex* sp.) or leaf litter (Ibid.). Rombough (2006) found most Foothill Yellow-legged Frogs under woody debris along the high-water line and often using seeps along the stream-edge, which provided them with moisture, a thermally stable environment, and prey.

Exceptions to the pattern of remaining near the stream's edge during winter have been reported. Cook et al. (2012) observed dozens of juvenile Foothill Yellow-legged Frogs traveling over land, as opposed to using riparian corridors. They were found using upland habitats with an average distance of 71.3 m (234 ft) from water (range: 16-331 m [52-1,086 ft]) (Ibid.). In another example, a single subadult that was found adjacent to a large wetland complex 830 m (2,723 ft) straight-line distance from the wetted edge of the Van Duzen River, although it is possible the wetland was connected to the river via a spillway or drainage that may have served as the movement corridor (CDFW 2018a, R. Bourque pers. comm. 2019).

Seasonal Activity and Movements

Because Foothill Yellow-legged Frogs occupy areas with relatively mild winter temperatures, they can be active year-round, although at low temperatures (< 7°C [44 °F], they become lethargic (Storer 1925, Zweifel 1955, Van Wagner 1996, Bourque 2008). They are active both day and night, and during the day adults are often observed basking on warm objects such as sun-heated rocks, although this is also when their detectability is highest (Fellers 2005, Wheeler et al. 2005). By contrast, Gonsolin (2010) tracked radio-telemetered Foothill Yellow-legged Frogs under substrate a third of the time and underwater a quarter of the time, although nearly all his detections of frogs without transmitters were basking.

Adult Foothill Yellow-legged Frogs migrate from their overwintering sites to breeding habitat in the spring, often from a tributary to its confluence with a larger stream or river. In areas where tributaries dry down, juveniles also make this downstream movement (Haggarty 2006). When the tributary itself is perennial and provides suitable breeding habitat, the frogs may not undertake these long-distance movements (Gonsolin 2010). Cues for adults to initiate this migration to breeding sites are somewhat enigmatic and vary by location, elevation, and amount of precipitation (S. Kupferberg and A. Lind pers. comm. 2017). They can also include day length, water temperature, and sex (GANDA 2008, Gonsolin 2010, Yarnell et al. 2010, Wheeler et al. 2018). Males initiate movements to breeding sites where they congregate in leks (areas of aggregation for courtship displays), and females arrive later and over a longer period (Wheeler and Welsh 2008, Gonsolin 2010). Most males utilize breeding sites associated with their overwintering tributaries, but some move substantial distances to other sites and may use more than one breeding site in the same season (Wheeler and Welsh 2006, GANDA 2008).

While the predictable hydrograph in California consists of wet winters with high flows and dry summers with low flows, the timing and quantity of seasonal discharge can vary significantly from year to year. The timing of oviposition can influence offspring growth and survival. Early breeders risk scouring of egg masses from their substrate by late spring storms in wet years or desiccation if waters recede rapidly, but when they successfully hatch, tadpoles benefit from a longer growing season, which can enable them to metamorphose at a larger size and increase their likelihood of survival (Railsback et al. 2016).

Later breeders are less likely to have their eggs scoured away or desiccated because flows are generally more stable, but they have fewer mate choices, and their tadpoles have a shorter growing period before metamorphosis, reducing their chance of survival (Ibid.). Some evidence indicates larger females, who coincidentally lay larger clutches, breed earlier (Kupferberg et al. 2009c, Gonsolin 2010). Consequently, early season scouring or stranding of egg masses or tadpoles can disproportionately impact the population's reproductive output because later breeders produce fewer and smaller eggs per clutch (Kupferberg et al. 2009c, Gonsolin 2010).

Timing of oviposition is often a function of water temperature and flow, but it consistently occurs on the descending limb of the hydrograph which corresponds to high winter discharge gradually receding toward low summer baseflow (Kupferberg 1996a, GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010, Yarnell et al. 2010). Under natural conditions, the timing coincides with intermittent tributaries drying down and increases in algal blooms that provide forage for tadpoles (Haggarty 2006, Power et al. 2008). At lower elevations, breeding can start in late March or early April, and at mid-elevations, breeding typically occurs in mid-May to mid-June (Gonsolin 2010, S. Kupferberg and A. Lind pers. comm. 2017). The time of year a population initiates breeding can vary by a month among water years, occurring later at deeper sites when colder water becomes warmer (Wheeler et al. 2018). In wetter years, delayed breeding into early July can occur in some colder snowmelt systems (S. Kupferberg and A. Lind pers. comm. 2017, GANDA 2018).

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A population's period of oviposition can also vary from two weeks to three months, meaning they could be considered explosive breeders at some sites and prolonged breeders at others (Storer 1925, Zweifel 1955, Van Wagner 1996, Ashton et al. 1997, Wheeler and Welsh 2008). Water temperature typically warms to over 10°C (50°F) before breeding commences (GANDA 2008, Gonsolin 2010, Wheeler et al. 2018). Wheeler and Welsh (2008) observed Foothill Yellow-legged Frogs breeding when flows were below 0.6 m/s (2 ft/s), pausing during increased flows until they receded, and GANDA (2008) reported breeding initiated when flow decreased to less than 55% above baseflow.

Male Foothill Yellow-legged Frogs spend more time at breeding sites during the season than females, many of whom leave immediately after laying their eggs (GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010). Daily movements are usually short (< 0.3 m [1 ft]), but some individuals travel substantial distances: median 70.7 m/d (232 ft/d) in spring and 37.1 m/d (104 ft/day) in fall/winter, nearly always using streams as movement corridors (Van Wagner 1996, Bourque 2008, Gonsolin 2010). The maximum reported movement rate is 1,386 m/d (0.86 mi/d), and the longest seasonal (post-breeding) daily distance reported is 7.04 km (4.37 mi) by a female that traveled up a dry tributary and over a ridge before returning to and moving up the mainstem creek (Bourque 2008). Movements during the non-breeding season are typically in response to drying channels or during rain events (Bourque 2008, Gonsolin 2010, Cook et al. 2012).

Hatchling Foothill Yellow-legged Frogs tend to remain with what is left of the egg mass for several days before dispersing into the interstitial spaces in the substrate (Ashton et al. 1997). They often move downstream in areas of moderate flow and will follow the location of warm water in the channel throughout the day (Brattstrom 1962, Ashton et al. 1997, Kupferberg et al. 2011a). Tadpoles usually

metamorphose in late August or early September (S. Kupferberg and A. Lind pers. comm. 2017). Twitty et al. (1967) reported that newly metamorphosed Foothill Yellow-legged Frogs mostly migrated upstream, which may be an evolutionary mechanism to return to their natal site after being washed downstream (Ashton et al. 1997).

Home Range and Territoriality

Foothill Yellow-legged Frogs exhibit a lek-type mating system in which males aggregate at the breeding site and establish calling territories (Wheeler and Welsh 2008, Bondi et al. 2013). The species has a relatively large calling repertoire for western North American ranids with seven unique vocalizations recorded (Silver 2017). Some of these can be reasonably attributed to territory defense and mate attraction communications (MacTeague and Northen 1993, Silver 2017). Physical aggression among males during the breeding season has been reported (Rombough and Hayes 2007, Wheeler and Welsh 2008). In addition, Wheeler and Welsh (2008) observed a non-random mating pattern in which males engaged in amplexus with females were larger than males never seen in amplexus, suggesting either physical competition or female preference for larger individuals. Very little information has been published on Foothill Yellow-legged Frog home range size. Wheeler and Welsh (2008) studied males during a 17-day period during breeding season and classified some of them "site faithful" based on their movements and calculated their home ranges. Two-thirds of males tracked were site faithful, and their mean home range size was 0.58 m^2 (SE = 0.10 m^2; 6.24 ft^2 [SE = 1.08 ft^2]) (Ibid.). In contrast, perhaps because the study took place over a longer time period, Bourque (2008) reported approximately half of the males he tracked during the spring were mobile, and the other half were sedentary. The median distances traveled along the creek (a proxy for home range size since they rarely leave the riparian corridor) for mobile and sedentary males were 149 m (489 ft) and 5.5 m (18 ft), respectively.

Diet and Predators

Foothill Yellow-legged Frog diet varies by life stage and likely body size. Tadpoles graze on periphyton (algae growing on submerged surfaces) scraped from rocks and vegetation and grow faster, and to a larger size, when it contains a greater proportion of epiphytic diatoms with nitrogen-fixing endosymbionts (*Epithemia* spp.), which are high in protein and fat (Kupferberg 1997b, Fellers 2005, Hayes et al. 2016, Catennazi and Kupferberg 2017). Tadpoles may also forage on necrotic tissue from dead bivalves and other tadpoles, or more likely the algae growing on them (Ashton et al. 1997, Hayes et al. 2016). Post-metamorphic Foothill Yellow-legged Frogs primarily feed on a wide variety of terrestrial arthropods but also some aquatic invertebrates (Fitch 1936, Van Wagner 1996, Haggarty 2006). Most of their diet consists of insects and arachnids (Van Wagner 1996, Haggarty 2006, Hothem et al. 2009). Haggarty (2006) did not identify any preferred taxonomic groups, but she noted larger Foothill Yellow-legged Frogs consumed a greater proportion of large prey items compared to smaller individuals, suggesting the species may be gape-limited generalist predators. Hothem et al. (2009) found mammal hair and bones in a Foothill Yellow-legged Frog. Adult Foothill Yellow-legged Frogs, like many other ranids, also cannibalize conspecifics (Wiseman and Bettaso 2007). In the fall when young-of-year are abundant, they may provide an important source of nutrition for adults prior to overwintering (Ibid.).

Foothill Yellow-legged Frogs are preyed upon by several native and introduced species, including each other as described above. Some predators target specific life stages, while others may consume multiple stages. Several species of gartersnakes (genus *Thamnophis*) are the primary and most widespread group of native predators on Foothill Yellow-legged Frogs tadpoles through adults is (Fitch 1941, Fox 1952, Zweifel 1955, Lind and Welsh 1994, Ashton et al. 1997, Wiseman and Bettaso 2007, Gonsolin 2010). Table 1 lists other known and suspected predators of Foothill Yellow-legged Frogs.

Table 1. Confirmed and potential Foothill Yellow-legged Frog predators in California in addition to gartersnakes (*Thamnophis* spp.)

Common Name	Scientific Name	Classification	Native	Prey Life Stage(s)	Sources
Caddisfly (larva)	*Dicosmoecus gilvipes*	Insect	Yes	Embryos (eggs)	Rombough and Hayes 2005
Dragonfly (nymph)	*Aeshna walker*	Insect	Yes	Larvae	Catenazzi and Kupferberg 2018
Waterscorpion	*Ranatra brevicollis*	Insect	Yes	Larvae	Catenaazi and Kupferberg 2018
Signal Crayfish	*Pacifastacus leniusculus*	Crustacean	No	Embryos (eggs) and Larvae	Rombough and Hayes 2005; Wiseman et al. 2005
Speckled Dace	*Rhinichthys osculus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Reticulate Sculpin	*Cottus perplexus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Sacramento Pike Minnow	*Ptychocheilus grandis*	Fish	Yes*	Embryos (eggs) and Adults	Ashton and Nakamoto 2007
Sunfishes	Family Centrachidae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Catfishes	Family Ictaluridae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Rough-skinned Newt	*Taricha granulosa*	Amphibian	Yes	Embryos (eggs)	Evenden 1948
California Giant Salamander	*Dicamptodon ensatus*	Amphibian	Yes	Larvae	Fidenci 2006
American Bullfrog	*Rana catesbeiana*	Amphibian	No	Larvae to Adults	Crayon 1998; Hothem et al. 2009
California Red-legged Frog	*Rana draytonii*	Amphibian	Yes	Larvae to Adults	Gonsolin 2010
American Robin	*Turdus migratorius*	Bird	Yes	Larvae	Gonsolin 2010
Common Merganser	*Mergus merganser*	Bird	Yes	Larvae	Gonsolin 2010
American Dipper	*Cinclus mexicanus*	Bird	Yes	Larvae	Ashton et al. 1997
Mallard	*Anas platyrhynchos*	Bird	Yes	Adults	Rombough et al. 2005
Raccoon	*Procyon lotor*	Mammal	Yes	Larvae to Adults	Zweifel 1955; Ashton et al. 1997
River Otter	*Lontra canadensis*	Mammal	Yes	Adults	T. Rose pers. comm. 2014

* Introduced to the Eel River, location of documented predation; Foothill Yellow-legged Frogs are extirpated from most areas of historical range overlap

STATUS AND TRENDS IN CALIFORNIA

Administrative Status

Sensitive Species

The Foothill Yellow-legged Frog is listed as a Sensitive Species by the U.S. Bureau of Land Management (BLM) and ~~U.S.~~ USDA Forest Service (Forest Service). These agencies define Sensitive Species as those species that require special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA.

California Species of Special Concern

The Department's Species of Special Concern (SSC) designation is similar to the federal Sensitive Species designation. It is administrative, rather than regulatory in nature, and intended to focus attention on animals at conservation risk. The designation is used to stimulate needed research on poorly known species and to target the conservation and recovery of these animals before they meet the CESA criteria for listing as threatened or endangered (Thomson et al. 2016). The Foothill Yellow-legged Frog is listed as a Priority 1 (highest risk) SSC (Ibid.).

Trends in Distribution and Abundance

Range-wide in California

Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551). Systematic, focused, range-wide assessments of Foothill Yellow-legged Frog distribution and abundance are rare, both historically and contemporarily. A detailed account of what has been documented within the National Parks and National Forests in California can be found in Appendix 3 of the *Foothill Yellow-legged Frogs Conservation Assessment in California* (Hayes et al. 2016).

Most Foothill Yellow-legged Frog records are incidental observations made during stream surveys for ESA-listed salmonids and simply document presence at a particular date and location, although some include counts or estimates of abundance by life stage. This makes assessing trends in distribution and abundance difficult despite a relatively large number of observations compared to many other species tracked by the California Natural Diversity Database (CNDDB). The CNDDB contained 2,366 Foothill Yellow-legged Frog occurrences in its March 2019 edition, 500 of which are documented from the past 5 years.

A few wide-ranging survey efforts that included Foothill Yellow-legged Frogs exist. Reports from early naturalists suggest Foothill Yellow-legged Frogs were relatively common in the Coast Ranges as far south as central Monterey County, in eastern Tehama County, and in the foothills in and near Yosemite National Park (Grinnell and Storer 1924, Storer 1925, Grinnell et al. 1930, Martin 1940). In addition to

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these areas, relatively large numbers of Foothill Yellow-legged Frogs (17-35 individuals) were collected at sites in the central and southern Sierra Nevada and the San Gabriel Mountains between 1911 and 1950 (Hayes et al. 2016). Widespread disappearances of Foothill Yellow-legged Frog populations were documented as early as the 1970s and 80s in southern California, the southern Coast Range, and the central and southern Sierra Nevada foothills (Moyle 1973, Sweet 1983).

Twenty-five years ago, the Department published the first edition of *Amphibians and Reptile Species of Special Concern in California* (Jennings and Hayes 1994). The authors revisited hundreds of localities that had historically been occupied by Foothill Yellow-legged Frogs between 1988 and 1991 and consulted local experts to determine presumed extant or extirpated status. Based on these survey results and stressors observed on the landscape, they considered Foothill Yellow-legged Frogs endangered in central and southern California south of the Salinas River in Monterey County. They considered the species threatened in the west slope drainages of the Cascade Mountains and Sierra Nevada east of the Central Valley, and they considered the remainder of the range to be of special concern (Ibid.).

Fellers (2005) and his field crews conducted surveys for Foothill Yellow-legged Frogs throughout California. They visited 804 sites across 40 counties with suitable habitat within the species' historical range. They detected at least one individual at 213 sites (26.5% of those surveyed) over 28 counties. They located Foothill Yellow-legged Frogs in approximately 40% of streams in the North Coast, 30% in the Cascade Mountains and south of San Francisco in the Coast Range, and 12% in the Sierra Nevada. Fellers estimated population abundance was 20 or more adults at only 14% of the sites where the species was found and noted the largest and most robust populations occurred along the North Coast. In addition, to determine status of Foothill Yellow-legged Frogs across the species' range and potential causes for declines, between 2000-2002, Lind (2005) used previously published status accounts, species expert and local biologist professional opinions, and field visits to historically occupied sites between 2000-2002. She determined that Foothill Yellow-legged Frogs had disappeared from 201 of 394 of the sites, representing just over 50%. The coarse-scale trend in California is one of greater population declines and extirpations in lower elevations and latitudes (Davidson et al. 2002).

Few site-specific population trend data are available from which to evaluate status. However, long-term monitoring efforts have often used egg mass counts as a proxy to estimate adult breeding females. The results of these studies ~~often~~ revealed extreme interannual variability in number of egg masses laid (Ashton et al. 2010, S. Kupferberg and M. Power pers. comm. 2015, Peek and Kupferberg 2016). In a meta-analysis of egg mass count data collected across the species' range in California over the past 25 years, Peek and Kupferberg (2016) reported declines in two unregulated rivers and an increase in another. Their models did not detect any significant trends in abundance across different locations or regulation type (dammed or undammed); however, high interannual variability can render trend detection difficult. Interannual variability was substantially greater in regulated rivers vs. unregulated; the median coefficient of variation was 66.9% and 41.6%, respectively (Ibid.). The greater variability in regulated rivers decreases the probability of detecting significant declines, and coupled with low abundance, it can lead to populations dropping below a density necessary for persistence without detection, resulting in extirpation.

Regional differences in Foothill Yellow-legged Frog persistence across its range have been recognized for nearly 50 years (i.e., more extirpations documented in the south). Because of these differences and the recent availability of new landscape genomic data, more detailed descriptions of trends in Foothill Yellow-legged Frog population distribution and abundance in California are evaluated by clade below. Figure 5 depicts Foothill Yellow-legged Frog localities across all clades in California by the most recent confirmed sighting in the datasets available to the Department within a Public Lands Survey System (PLSS) section. “Transition Zones” are those areas where the exact clade boundaries are unknown due to a lack of samples. In addition, while not depicted as an area of uncertainty, no genetic samples have been ~~tested~~ evaluated from south of the extant population in northern San Luis Obispo County, in the Sutter Buttes in Sutter County, or northeastern Plumas County. It is possible there were historically more clades than is currently understood.

Caution should be exercised in comparing the following observation data across the species’ range and across time since survey effort and reporting are not standardized. These data can be useful for making some general inferences about distribution, abundance, and trends. For instance, assuming the observation correctly identifies the species, the date on the record is the last time the species was confirmed to have occurred at that location. However, this only works in the affirmative. For example, at a site where the last time the species was seen was 75 years ago, the species may still persist there if no one has surveyed it since the original observation. CNDDB staff use information on land use conversion, follow-up visits, and biological reports to categorize an occurrence location as “extirpated” or “possibly extirpated”.

Northwest/North Coast Clade

This clade extends from north of San Francisco Bay through the Coast Range and Klamath Mountains to the northern limit of the Foothill Yellow-legged Frog’s range and east through the Cascade Range. It includes Del Norte, Siskiyou, Humboldt, Trinity, Shasta, Tehama, Mendocino, Glenn, Colusa, Lake, Sonoma, Napa, Yolo, Solano, and Marin counties. This clade covers the largest geographic area and contains the greatest amount of genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). In addition, it is the only clade with an increasing trend in genetic diversity (Peek 2018).

Early records note the comparatively high abundance of Foothill Yellow-legged Frogs in this area. Storer (1925) described Foothill Yellow-legged Frogs as very common in many of Coast Range streams north of San Francisco Bay, and Cope (1879, 1883 as cited in Hayes et al. 2016) noted they were “rather abundant in the mountainous regions of northern California.” In addition, relatively large collections occurred over short periods of time in this region in the late 1800s and the first half of the 20th century (Hayes et al. 2016). Nineteen were taken over two weeks in 1893 along Orrs Creek, a tributary to the Russian River, and 40 from near Willits (both in Mendocino County) in 1911; 112 were collected over three days at Skaggs Spring (Sonoma County) in 1911; 57 were taken in one day along Lagunitas Creek (Marin County) in 1928; and 50 were collected in one day near Denny (Trinity County) in 1955 (Ibid.).

A few long-term Foothill Yellow-legged Frog egg mass monitoring efforts undertaken within this clade’s boundaries found densities vary significantly, often based on river regulation type, and documented

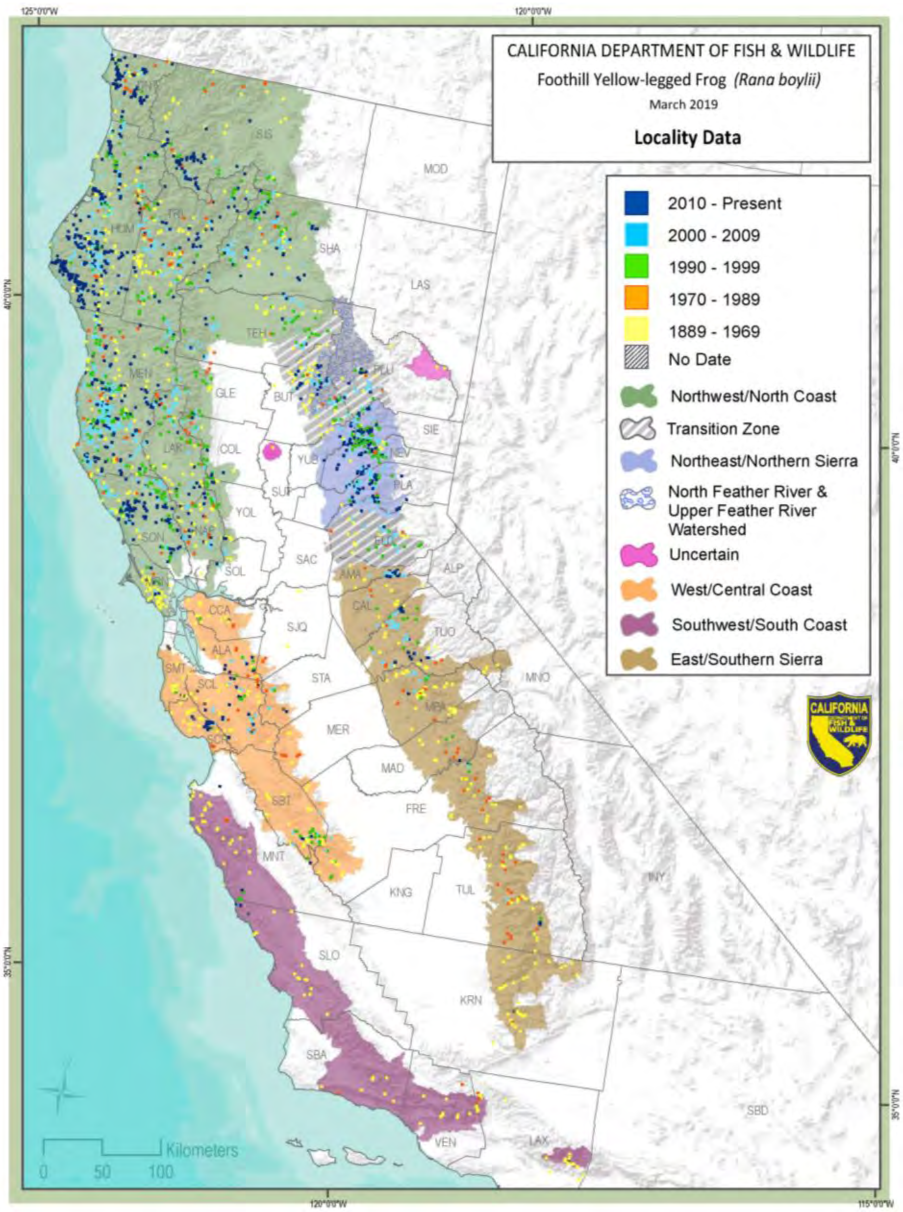

Figure 5. Foothill Yellow-legged Frog occurrence data from 1889-2019 overlaying the six clades by most recent sighting in a Public Lands Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

several robust populations. The Green Diamond Resources Company has been monitoring a stretch of the Mad River near Blue Lake (Humboldt County) since 2008 (GDRC 2018). The greatest published density of Foothill Yellow-legged Frog egg masses was documented here in 2009 at 323.6 egg masses/km (520.7/mi) (Bourque and Bettaso 2011). However, in 2017, surveyors counted 625.1 egg masses/km (1,006/mi) along the same reach (GDRC 2018). At its lowest during this period, egg mass density was calculated at 71.54/km (115.1/mi) in 2010, although this count occurred after a flooding even that likely scoured over half of the egg masses laid that season (GDRC 2018, R. Bourque pers. comm. 2019). During a single day survey in 2017 along approximately 2 km (1.3 mi) of Redwood Creek in Redwood National Park (Humboldt County), 2,009 young and 126 adult Foothill Yellow-legged Frogs were found (D. Anderson pers. comm. 2017). Some reaches of the South Fork Eel River (Mendocino County) also support high densities of Foothill Yellow-legged Frogs. Kupferberg (pers. comm. 2018) recorded 206.9 and 106.2 egg masses/km (333 and 171/mi) along two stretches in 2016, and 201.7 and 117.5 egg masses/km (324 and 189/mi) in 2017. However, other reaches yielded counts as low as 6.1 and 8.4 egg masses/km (9.8 and 13.5/mi) (Ibid.). In the Angelo Reserve (an unregulated reach), the 24-year mean density was 109 egg masses/km (175.4/mi) (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015). In contrast, a 10-year mean density of egg masses below Lewiston Dam on the Trinity River (Trinity County) was 0.89/km (1.43/mi) (Ibid.).

Figure 6 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, Biological Information Observation System datasets, and personal communications that are color coded by the most recent date of detection. Within this clade, Foothill Yellow-legged Frogs were observed in at least 343 areas in the past 5 years (CNDDB 2019). The species remains widespread within many watersheds, although most observations only verify presence, or fewer than ten individuals or egg masses are recorded (Ibid.). Documented extirpations are comparatively rare, but also likely undetected or under-reported, and nearly all occurred just north of the high-populated San Francisco Bay area (Figure 7; Ibid.).

West/Central Coast

This clade extends south from the San Francisco Bay through the Diablo Range and down the peninsula through the Santa Cruz and Gabilan Mountains in the Coast Range east of the Salinas Valley. It includes most of Contra Costa, Alameda, San Mateo, Santa Cruz, Santa Clara, and San Benito counties; western San Joaquin, Stanislaus, Merced, and Fresno counties; and a small portion of eastern Monterey County. Records of Foothill Yellow-legged Frogs occurring south of San Francisco Bay did not exist until specimens were collected in 1918 around what is now Pinnacles National Park in San Benito County, and little information exists on historical distribution and abundance within this clade (Storer 1923).

Within this clade, Foothill Yellow-legged Frogs were observed in at least 24 areas in the past five years (Figure 8; CNDDB 2019). Documented and possible extirpations are concentrated around the San Francisco Bay and sites at the southern portion of the clade's range, although these may not have been resurveyed since their original observations in the 1940s through 1960s, except for a site in Pinnacles National Park that was surveyed in 1994 (Figure 9; Ibid.). In addition, although not depicted,

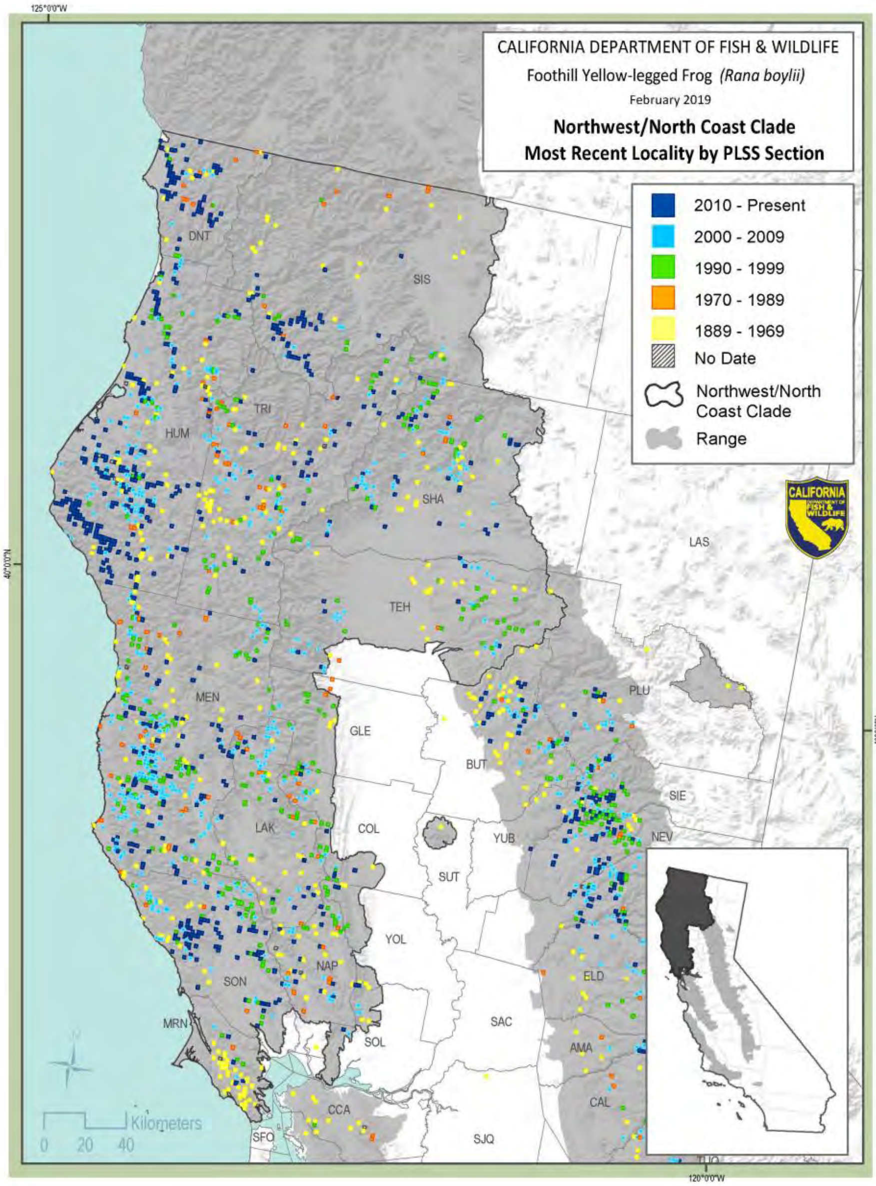

Figure 6. Close-up of Northwest/North Coast Foothill Yellow-legged Frog clade observations from 1889-2019 (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

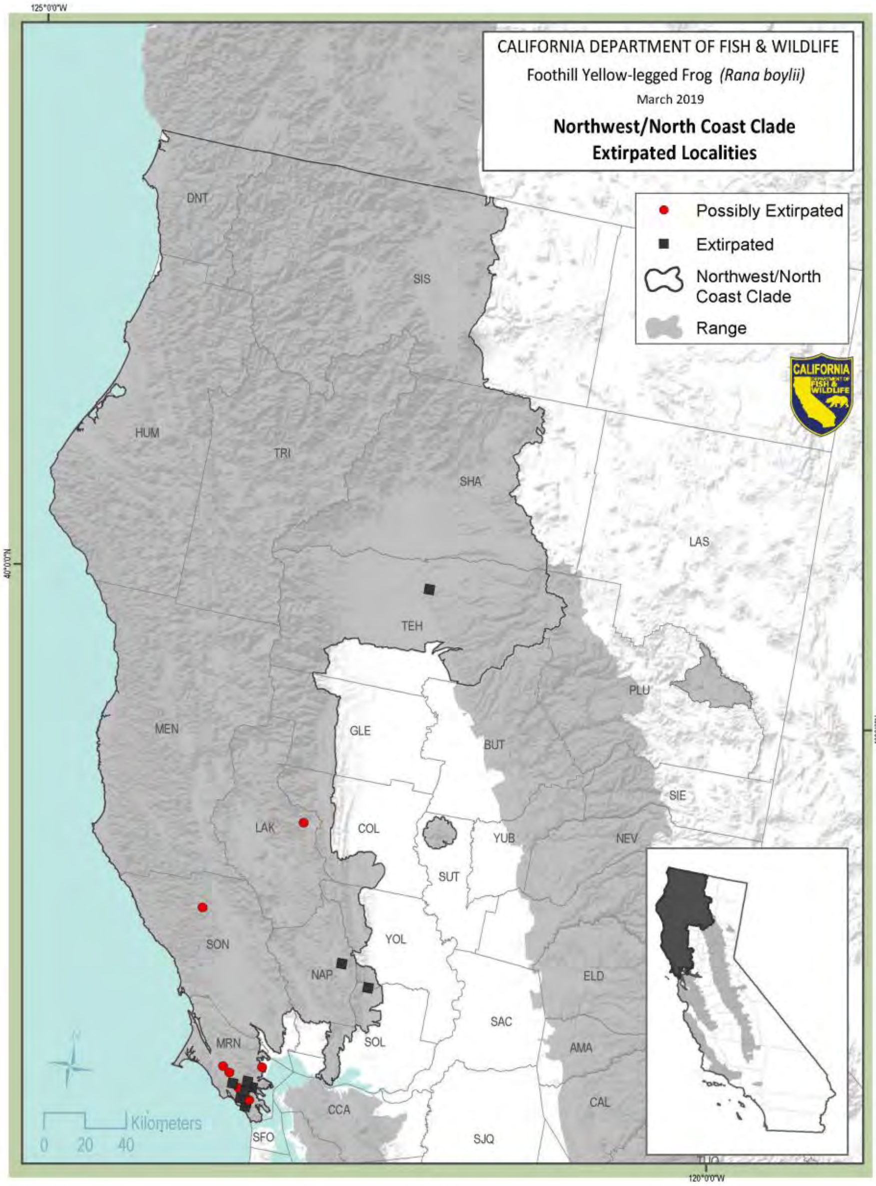

Figure 7. Possibly extirpated and extirpated Northwest/North Coast Foothill Yellow-legged Frog clade sites (CNDDB)

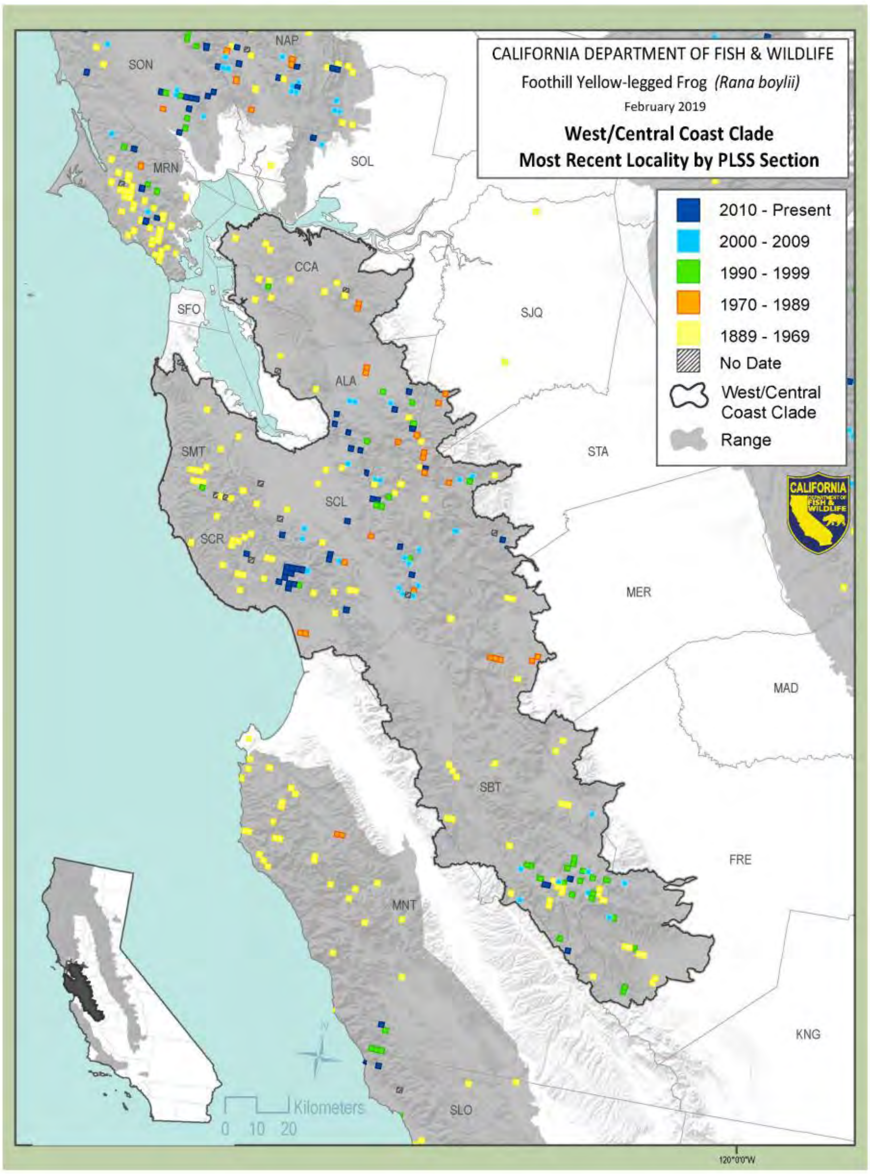

Figure 8. Close-up of West/Central Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

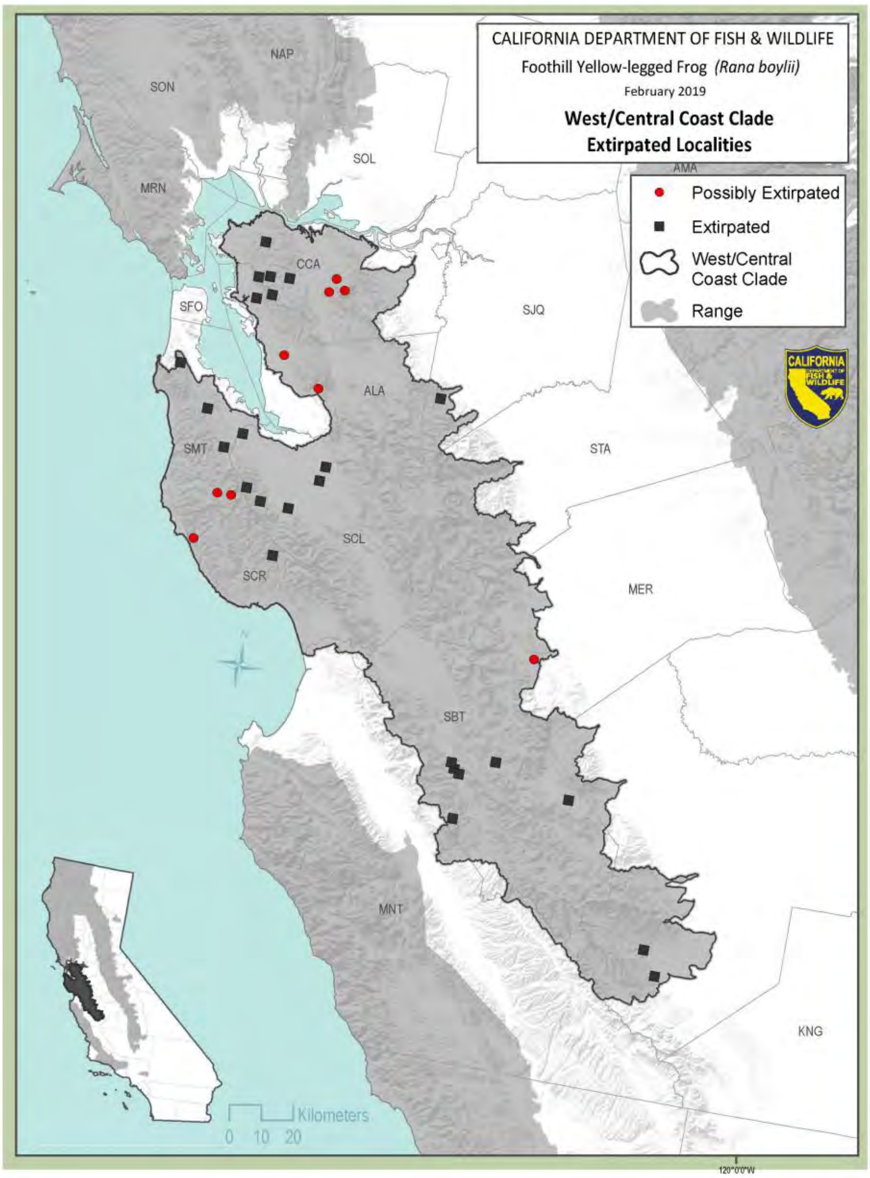

Figure 9. Possibly extirpated and extirpated West/Central Coast Foothill Yellow-legged Frog clade sites (CNDDB)

two populations on Arroyo Mocho and Arroyo Valle south of Livermore (Alameda County) are also likely extirpated (M. Grefsrud pers. comm. 2019).

The San Francisco Bay Area is heavily urbanized. Foothill Yellow-legged Frogs may be gone from Contra Costa County; eight of the nine CNDDB records from the county are museum specimens collected between 1891 and 1953, and the most recent observation was two adults in a plunge pool in an intermittent tributary to Moraga Creek in 1997. No recent (2010 or later) observations exist from San Mateo County (Ibid.). Historically occupied lower-elevation sites surrounding the San Francisco Bay and inland appear to be extirpated, but there are (or were) some moderately abundant breeding populations remaining at higher elevations in Arroyo Hondo (Alameda County), Alameda Creek (Alameda and Santa Clara counties), Coyote and Upper Llagas creeks (Santa Clara County), and Soquel Creek (Santa Cruz County) with some scattered smaller populations also persisting in these counties (J. Smith pers. comm. 2016, 2017; CNDDB 2019). The Alameda Creek and Coyote Creek populations recently underwent large-scale mortality events, so their numbers are likely substantially lower than what is currently reported in the CNDDB (Adams et al. 2017a, Kupferberg and Catenazzi 2019). In addition, the Arroyo Hondo population will lose approximately 1.6 km (1 mi) of prime breeding habitat (i.e., supported the highest density of egg masses on the creek) as the Calaveras Reservoir is refilled following its dam replacement project in 2019 (M. Grefsrud pers. comm. 2019). Foothill Yellow-legged Frogs may be extirpated from Corral Hollow Creek in San Joaquin County, but a single individual was observed five years ago further up the drainage in Alameda County within an Off-Highway Vehicle park (CNDDB 2019). Few recent sightings of Foothill Yellow-legged Frogs in the east-flowing creeks are documented. They may still be extant in the headwaters of Del Puerto Creek (western Stanislaus County), but the records further downstream indicate bullfrogs (known predators and disease reservoirs) are moving up the system (Ibid.). Several locations in southern San Benito, western Fresno, and eastern Monterey counties have relatively recent (2000 and later) detections (Ibid.). However, while many of these sites supported somewhat large populations in the 1990s, the more recent records report fewer than ten individuals (Ibid.). The exception is a Monterey County site where around 25 to 30 were observed in 2012 (Ibid.).

Southwest/South Coast

Widespread extirpations occurred decades ago, primarily in the 1960s and 1970s, in this area (Adams et al. 2017b). As a result, genetic samples were largely unavailable, and the boundaries are speculative. The clade is presumed to include the Coast Range from Monterey Bay south to the Transverse Range across to the San Gabriel Mountains. This clade includes portions of Monterey, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties. Storer (1923) reported that Foothill Yellow-legged Frogs were collected for the first time in Monterey County in 1919 and that a specimen collected by Cope in 1889 in Santa Barbara and listed as *Rana temporaria pretiosa* may refer to the Foothill Yellow-legged Frog because as previously mentioned, the taxonomy of this species changed several times over the first century after it was named.

Foothill Yellow-legged Frogs had been widespread and fairly abundant in this area until the late 1960s (Figure 10) but were rapidly extirpated throughout the southern Coast Ranges and western Transverse

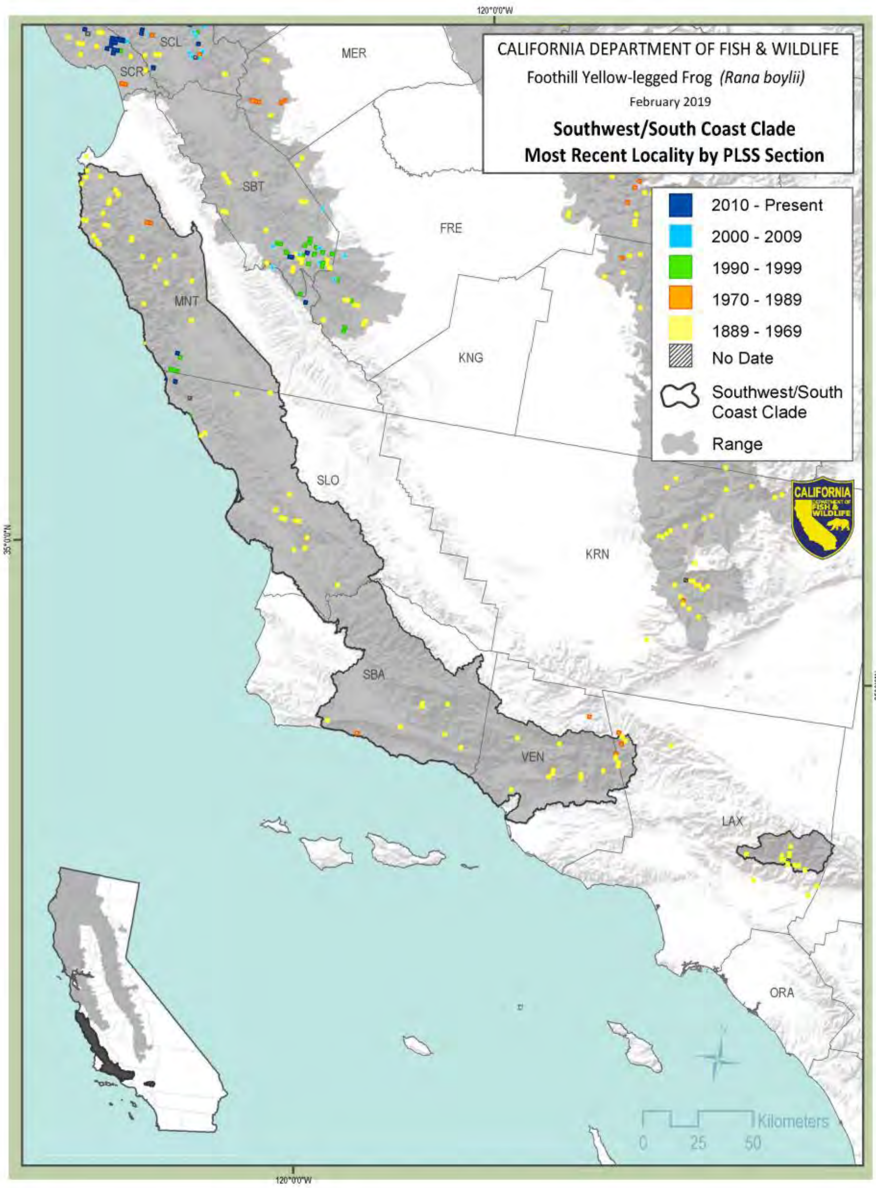

Figure 10. Close-up of Southwest/South Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

Ranges by the mid-1970s (Figure 11; Sweet 1983, Adams et al. 2017b). Only two known extant populations exist from this clade, located near the border of Monterey and San Luis Obispo counties (S. Sweet pers. comm. 2017, McCartney-Melstad et al. 2018, Peek 2018, CNDDB 2019). They appear to be extremely small and rapidly losing genetic diversity, making them at high risk of extirpation (McCartney-Melstad et al. 2018, Peek 2018).

Northeast/Feather River and Northern Sierra

The exact clade boundaries in the Sierra Nevada are unclear and will require additional sampling and testing to define (Figure 12). The Northeast clade presumably encompasses the Feather River and Northern Sierra clades. The Feather River clade is located primarily in Plumas and Butte counties. The Northern Sierra clade roughly extends from the Feather River watershed south to the Middle Fork American River. It includes portions of El Dorado, Placer, Nevada, Sierra, and Plumas counties. It may also include portions of Amador, Butte, and eastern Tehama counties. No genetic samples were available to test in the Sutter Buttes or the disjunct population in northeastern Plumas County to determine which clades they belonged to before they were extirpated (Figure 13; Olson et al. 2016, CNDDB 2019).

In general, there is a paucity of historical Foothill Yellow-legged Frog data for west-slope Sierra Nevada streams, particularly in the lower elevations of the Sacramento Valley, and no quantitative abundance data exist prior to major changes in the landscape (i.e., mining, dams, and diversions) or the introduction of non-native species (Hayes et al. 2016). Foothill Yellow-legged Frogs have been collected frequently from the Plumas National Forest area in small numbers from the turn of the 20th century through the 1970s (Ibid.). Estimates of relative abundance are not clear from the records, but they suggest the species was somewhat widespread in this area.

More recently, Foothill Yellow-legged Frog populations in the Sierra Nevada have been the subject of a substantial number of surveys and focused research associated with recent and ongoing relicensing of hydroelectric power generating dams by the Federal Energy Regulatory Commission (FERC). Consequently, Foothill Yellow-legged Frogs have been observed in at least 30 areas in Plumas and Butte counties (roughly the Feather River clade) over the past five years (CNDDB 2019). As with the rest of the range, most records are observations of only a few individuals; however, many observations occurred over multiple years, and in some cases all life stages were observed over multiple years (Ibid). The populations appear to persist even with the small numbers reported. The only long-term consistent survey effort has been occurring on the North Fork Feather River along the Cresta and Poe reaches (GANDA 2018). The Cresta reach's subpopulation declined significantly in 2006 and never recovered despite modification of the flow regime to reduce egg mass and tadpole scouring and some habitat restoration (Ibid.). A pilot project to augment the Cresta reach's subpopulation through in situ captive rearing was initiated in 2017 (Dillingham et al. 2018). It resulted in the highest number of young-of-year Foothill Yellow-legged Frogs recorded during fall surveys since researchers started keeping count (Ibid.). The number of egg masses laid in the Poe reach varies substantially year-to-year from a low of 26 in 2001 to a high of 154 in 2015 and back down to 36 in 2017 (GANDA 2018).

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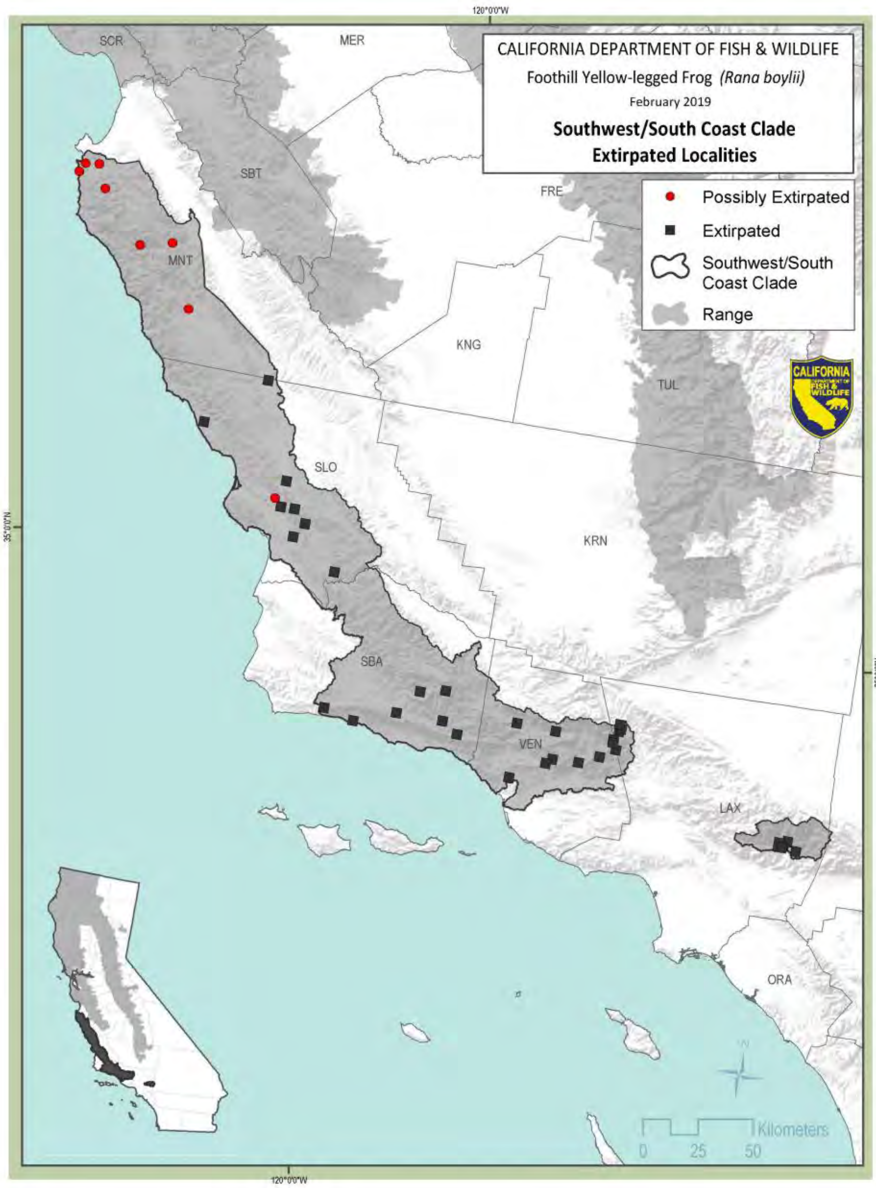

Figure 11. Possibly extirpated and extirpated Southwest/South Coast Foothill Yellow-legged Frog clade sites (CNDDB)

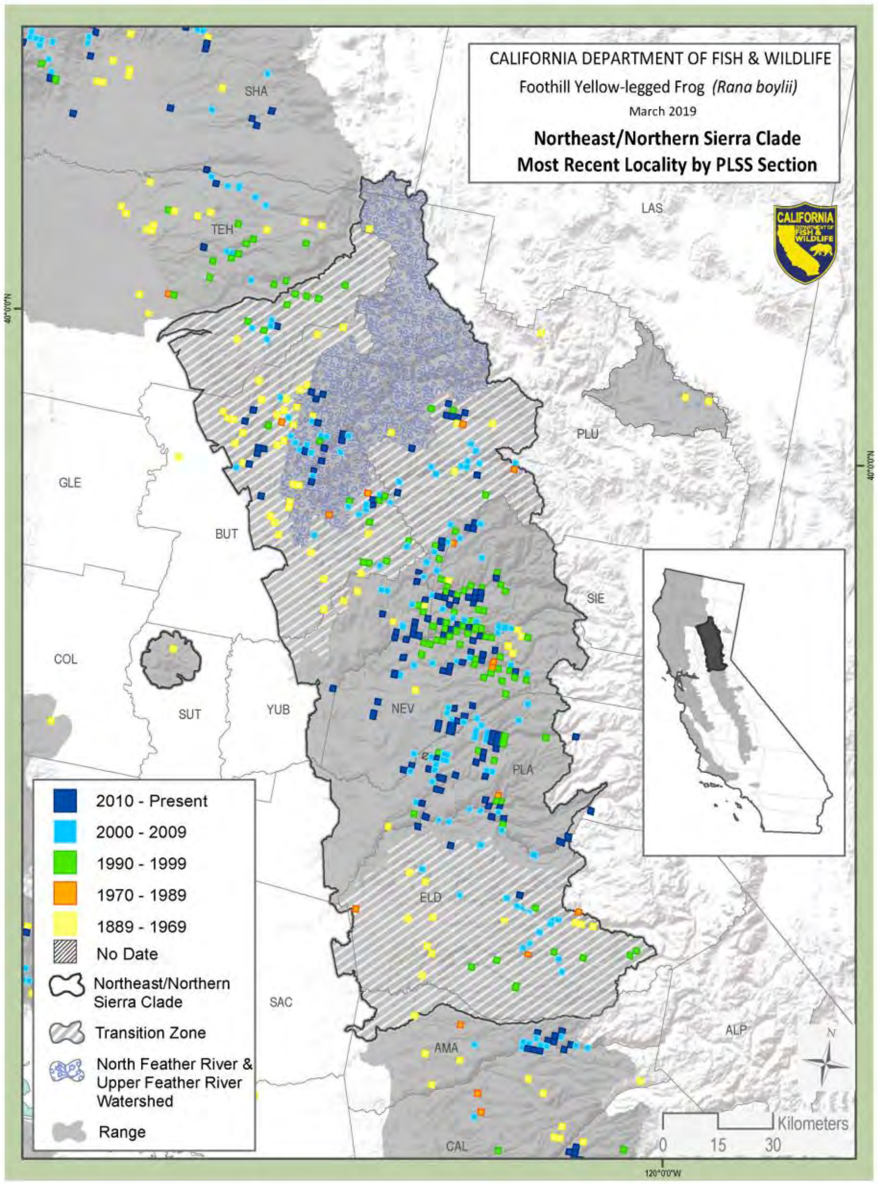

Figure 12. Close-up of Northeast/Feather River and Northern Sierra clades observations from 1889-2019 (ARSSC, BIOS, CNDDB)

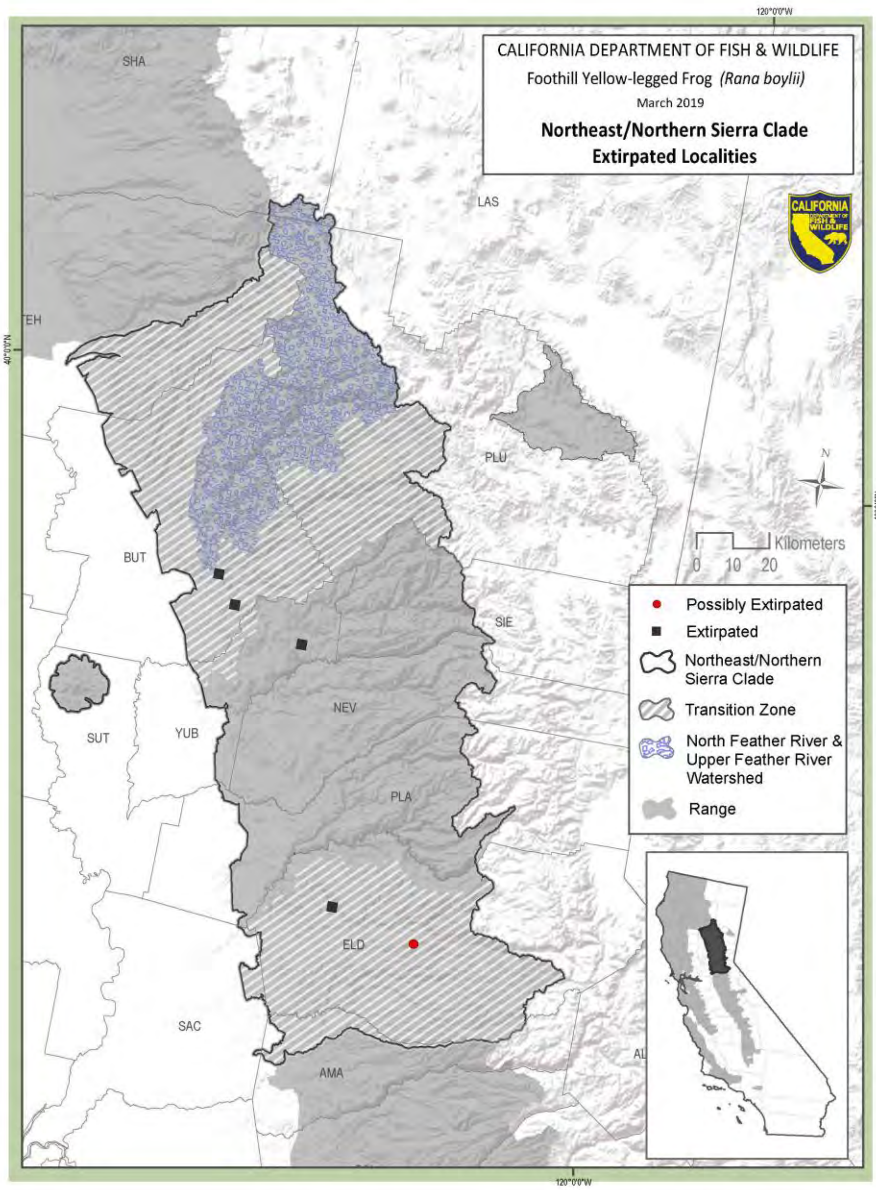

Figure 13. Possibly extirpated and extirpated Northeast/Feather River and Northern Sierra Foothill Yellow-legged Frog clades sites (CNDDB)

Foothill Yellow-legged Frogs have been observed in at least 71 areas in the past 5 years in the presumptive Northeast/Northern Sierra clade. The general pattern in this clade, and across the range for that matter, is that unregulated rivers or reaches have more areas that are occupied more consistently and in larger numbers than regulated rivers or reaches (CNDDB 2019, S. Kupferberg pers. comm. 2019). Foothill Yellow-legged Frogs were rarely observed in the hydropeaking reach of the Middle Fork American River and were observed in low numbers in the bypass reach, but they were present and breeding in small tributary populations (PCWA 2008). Relatively robust populations appear to inhabit the North Fork American River and Lower Rubicon River (Gaos and Bogan 2001, PCWA 2008, Hogan and Zuber 2012, K. Kundargi pers. comm. 2014, S. Kupferberg pers. comm. 2019). Additional apparently sufficiently large and relatively stable populations occur on Clear Creek, South Fork Greenhorn Creek, and Shady Creek (Nevada County) and the North and Middle Yuba River (Sierra County), but the remaining observations are of small numbers in tributaries with minimal connectivity among them (CNDDB 2019, S. Kupferberg pers. comm. 2019).

East/Southern Sierra

The East/Southern Sierra clade is presumed to range from the South Fork American River watershed, the northernmost site where individuals from this clade were collected, south to where the Sierra Nevada meets the Tehachapi Mountains. It likely includes El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, Fresno, Tulare, and Kern counties (Figure 14; Peek 2018). The proportion of extirpated sites in this clade is second only to the Southwest/South Coast and follows the pattern of greater losses in the south (Figure 15). Like the southern coastal clade, the southern Sierra clade has low genetic variability and a trajectory of continued loss of diversity (Ibid.).

Historical collections of small numbers of Foothill Yellow-legged Frogs occurred in every major river system within this clade beginning as early as the turn of the 20th century, indicating widespread distribution but little information on abundance (Hayes et al. 2016). By the early 1970s, declines in Foothill Yellow-legged Frog populations from this area were already apparent; Moyle (1973) found them at 30 of 95 sites surveyed in 1970. Notably bullfrogs inhabited the other 65 sites formerly occupied by Foothill Yellow-legged Frogs, and they co-occurred at only 3 sites (Ibid.). In 1992, Drost and Fellers (1996) revisited the sites around Yosemite National Park (Tuolumne and Mariposa counties) that Grinnell and Storer (1924) surveyed in 1915 and 1919. Foothill Yellow-legged Frogs had disappeared from all seven historically occupied sites and were not found at any new sites surveyed surrounding the park (Ibid.). Resurveys of previously occupied sites on the Stanislaus (Tuolumne County), Sierra (Fresno County), and Sequoia (Tulare County) National Forests were also undertaken (Lind et al. 2003b). Foothill Yellow-legged Frogs were absent from the sites in Sierra and Sequoia National Forests, six at each forest; however, a new population was discovered in the Sierra and two in the Sequoia forests (Ibid.). These populations remain extant but are small and isolated (CNDDB 2019). Two of the six sites on the Stanislaus were still occupied, and 19 new populations were found with evidence of breeding at seven of them (Lind et al. 2003b). Twenty of the 24 populations extant at the time inhabited unregulated waterways (Ibid.). Most of the CNDDB (2019) records of Foothill Yellow-legged Frogs on the Stanislaus are at least a decade old and are represented by low numbers.

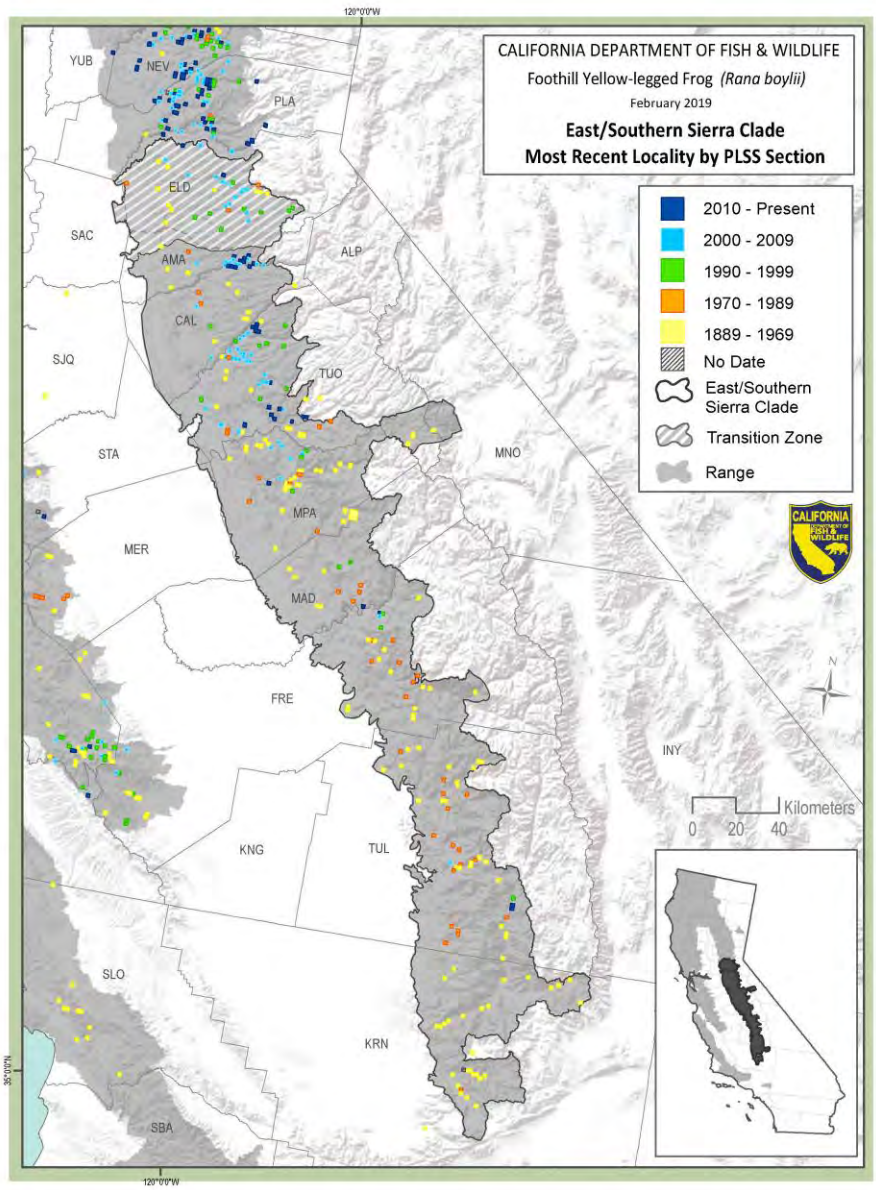

Figure 14. Close-up of East/Southern Sierra clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

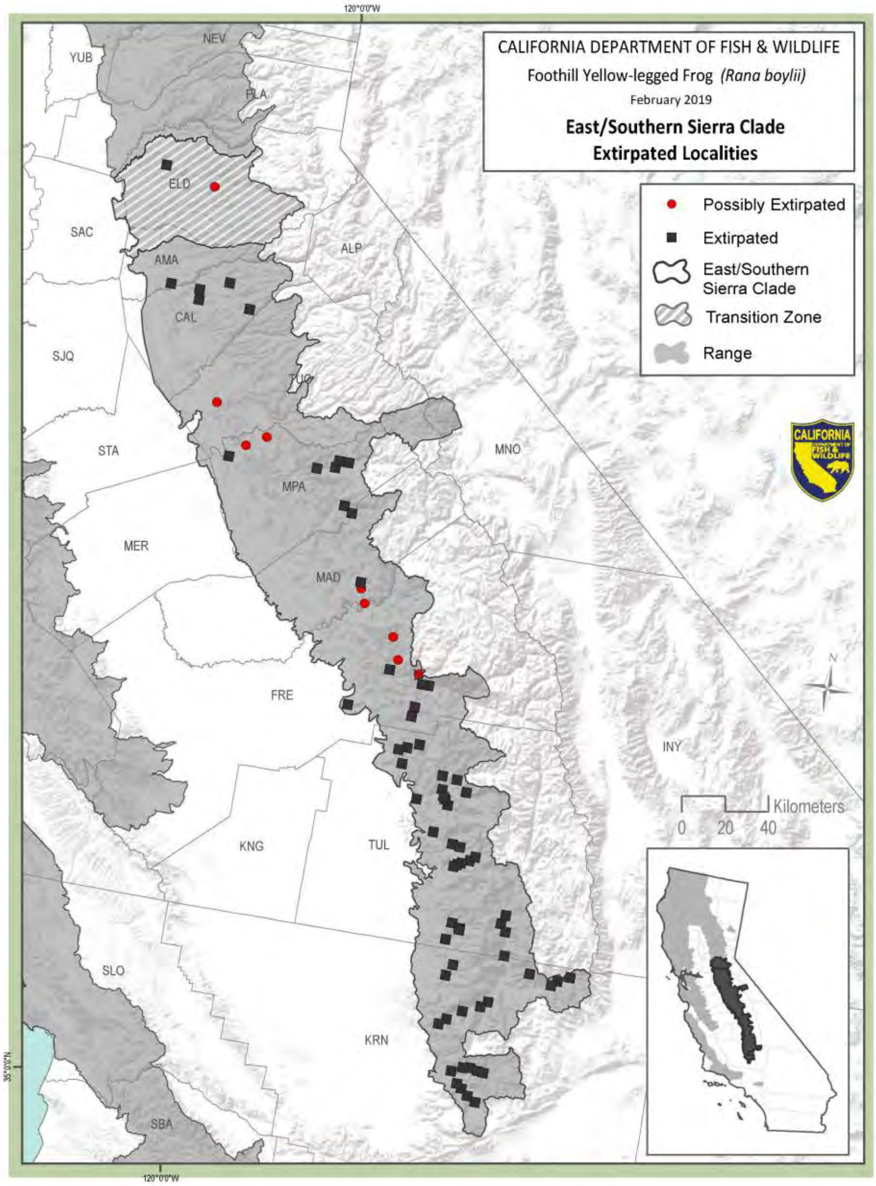

Figure 15. Possibly extirpated and extirpated East/Southern Sierra Foothill Yellow-legged Frog clade sites (CNDDB)

More recently, surveys for Foothill Yellow-legged Frogs were conducted along the South Fork American River as part of the El Dorado Hydroelectric Project's FERC license amphibian monitoring requirements (GANDA 2017). Between 2002 and 2016 counts of different life stages varied significantly by year but the trend for every life stage was a decline over that period (Ibid.). There appears to be a small population persisting along the North Fork Mokelumne River (Amador and Calaveras counties), but it was only productive during the 2012-2014 drought years (Ibid.). Small numbers have also been observed recently in several locations on private timberlands in Tuolumne County (CNDDB 2019).

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FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

"The fortunes of the boylii *population fluctuate with those of the stream"* - Tracy I. Storer, 1925

Several past and ongoing activities have changed the watersheds upon which Foothill Yellow-legged Frogs depend, and many interact with each other exacerbating their adverse impacts. With such an expansive range in California, the degree and severity of these impacts on the species often vary by location. To the extent feasible based on the best scientific information available, those differences are discussed below.

Dams, Diversions, and Water Operations

Foothill Yellow-legged Frogs evolved in a Mediterranean climate with predictable cool, wet winters and hot, dry summers, with their life cycle is adapted to these conditions. In California and other areas with a Mediterranean climate, human demands for water are at the highest when runoff and precipitation are lowest, and annual water supply varies significantly but always follows the general pattern of peak discharge declining to baseflow in the late spring or summer (Grantham et al. 2010). The Foothill Yellow-legged Frog's life cycle depends on this discharge pattern and the specific habitat conditions it produces (see the Breeding and Rearing Habitat section). Dams are ubiquitous, but not evenly distributed, in California. Figure 16 depicts the locations of dams under the jurisdiction of the Army Corps of Engineers (ACOE) and the California Department of Water Resources (DWR). Figure 17 depicts the number of surface diversions per PLSS section within the Foothill Yellow-legged Frog's range (eWRIMS 2019).

Dam operations frequently change the amount and timing of water availability; its temperature, depth, and velocity; and its sediment transport and channel morphology altering functions, which can result in dramatic consequences on the Foothill Yellow-legged Frog's ability to survive and successfully reproduce. Several studies comparing Foothill Yellow-legged Frog populations in regulated and unregulated reaches within the same watershed investigate potential dam-effects. These studies demonstrated that dams and their operations can result in several factors that contribute to population declines and possible extirpation. These factors include confusing breeding cues, scouring and stranding of egg masses and tadpoles, reduced quality and quantity of breeding and rearing habitat, reduced tadpole growth rate, barriers to gene flow, and establishment and spread of non-native species (Hayes et al. 2016). In addition, as previously discussed in the Population Structure and Genetic Diversity section, subpopulations of Foothill Yellow-legged Frogs on regulated rivers are more isolated, and the

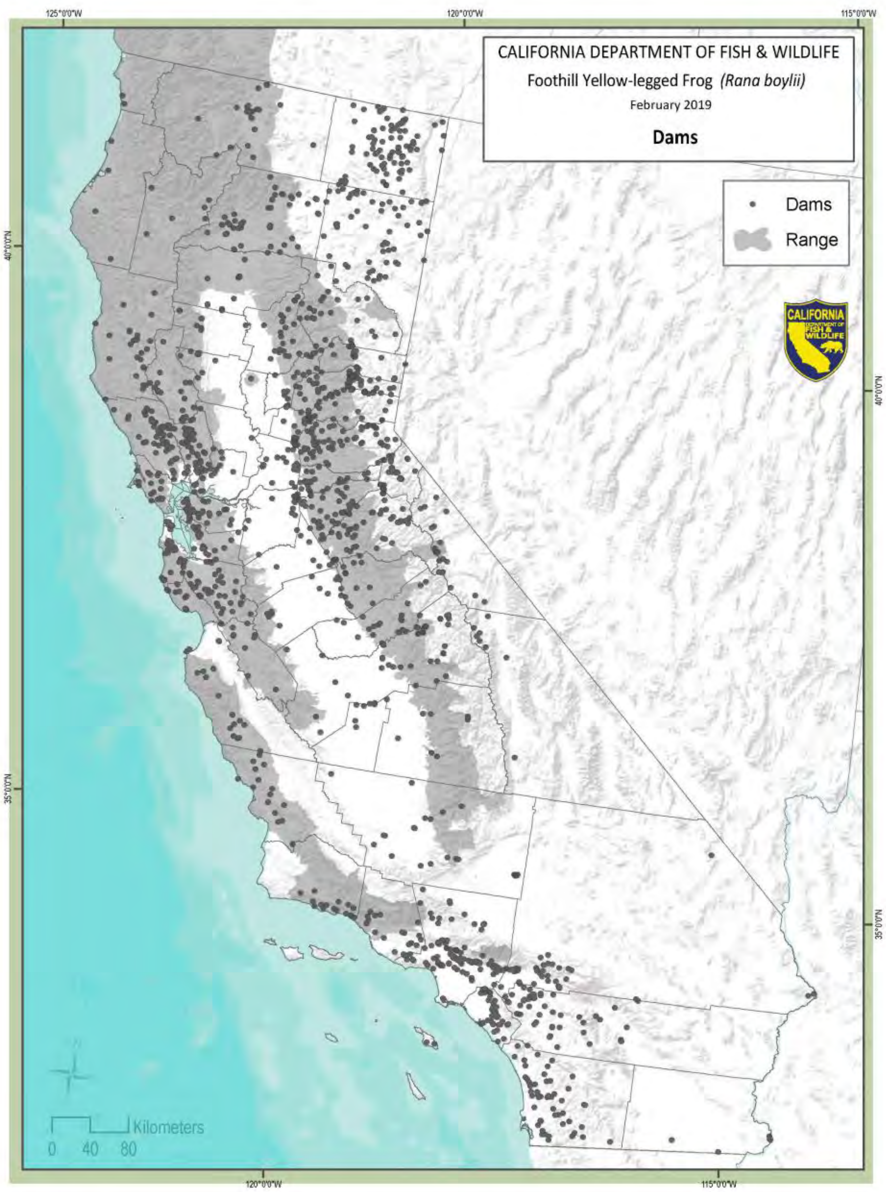


Figure 16. Locations of ACOE and DWR jurisdictional dams (DWR, FRS)

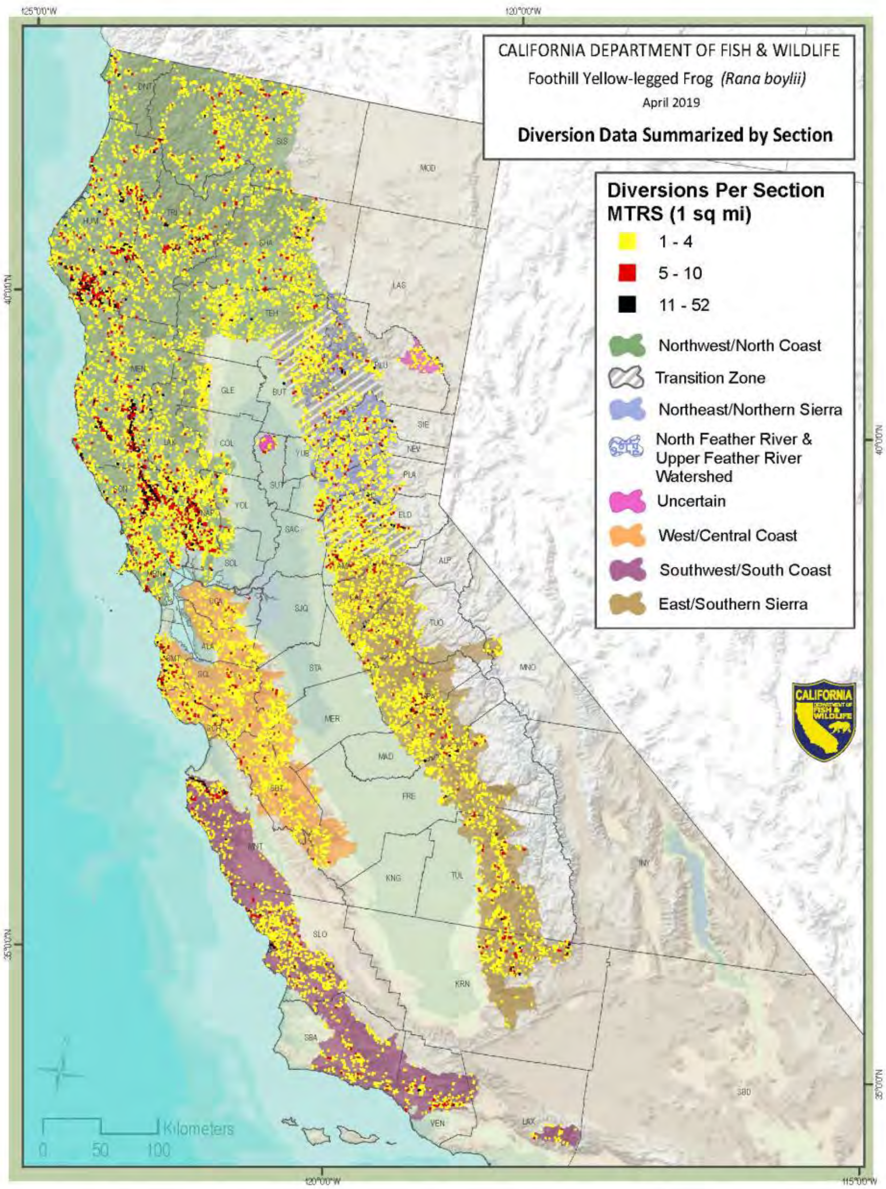


Figure 17. Number of surface water diversions per Public Lands Survey System section within the Foothill Yellow-legged Frog's range in California (eWRIMs)

type of water operations (hydropeaking vs. bypass flows) significantly affects the degree of gene flow loss among them (Peek 2011, 2018). Figure 18 depicts the locations of hydroelectric power plants.

As discussed in the Seasonal Activity and Movements section, cues for Foothill Yellow-legged Frogs to start breeding appear to involve water temperature and velocity, two features altered by dams. Dam operations typically result in reduced flows that are more stable over the course of a year than unimpaired conditions, and dam managers are frequently required to maintain thermally appropriate water temperatures and flows for cold-water-adapted salmonids (USFWS and Hoopa Valley Tribe 1999, Wheeler et al. 2014). For example, late-spring and summer water temperatures on the mainstem Trinity River below Lewiston Dam have been reported to be up to 10°C (20°F) cooler than average pre-dam temperatures, while average winter temperatures are slightly warmer (USFWS and Hoopa Valley Tribe 1999). As a result, Foothill Yellow-legged Frogs breed later on the mainstem Trinity River compared to six nearby tributaries, and some mainstem reaches may never attain the minimum required temperature for breeding (Wheeler et al. 2014, Snover and Adams 2016). In addition, annual discharges past Lewiston Dam have been 10-30% of pre-dam flows and do not mimic the natural hydrograph (Lind et al. 1996).

Aseasonal discharges from dams occur for several reasons including increased flow in late-spring and early summer to facilitate outmigration of salmonids, channel maintenance pulse flows, short-duration releases for recreational whitewater boating, rapid reductions after a spill (uncontrolled flows released down a spillway when reservoir capacity is exceeded) to retain water for power generation or water supply later in the year, peaking flows for hydroelectric power generation, and sustained releases to maintain the seismic integrity of the dam (Lind et al. 1996, Jackman et al. 2004, Kupferberg et al. 2011b, Kupferberg et al. 2012, Snover and Adams 2016). The results of a Foothill Yellow-legged Frog population viability analysis (PVA) suggest that the likelihood a population will persist is very sensitive to early life stage mortality; the 30-year probability of extinction increases significantly with high levels of egg or tadpole scouring or stranding (Kupferberg et al. 2009c). For instance, in 1991 and 1992, all egg masses laid before high flow releases to encourage outmigration of salmonids on the Trinity River were scoured away (Lind et al. 1996). According to the PVA, even a single annual pulse flow such as this or for recreational boating, can result in a three- to five-fold increase in the 30-year extinction risk based on amount of tadpole mortality experienced (Kupferberg et al. 2009c). Management after natural spills can also lead to substantial mortality. For example, in 2006, Foothill Yellow-legged Frogs on the North Fork Feather River bred during a prolonged spill, and the rapid recession below Cresta Dam that followed stranded and desiccated all the eggs laid (Kupferberg et al. 2009b). Rapid flows can also increase predation risk if tadpoles are forced to seek shelter under rocks where crayfish and other invertebrate predators are more common or if they are displaced into the water column where their risk of predation by fish is greater (Ibid.).

The overall reduction of flows and frequency of large winter floods below dams can produce extensive changes to Foothill Yellow-legged Frog habitat quality. They reduce the formation of river bars that are regularly used as breeding habitat, and they create deeper and steeper channels with less complexity and fewer warm, calm, shallow edgewater habitats for tadpole rearing (Lind et al. 1996, Wheeler and Welsh 2008, Kupferberg et al. 2011b, Wheeler et al. 2014). For example, 26 years after construction of

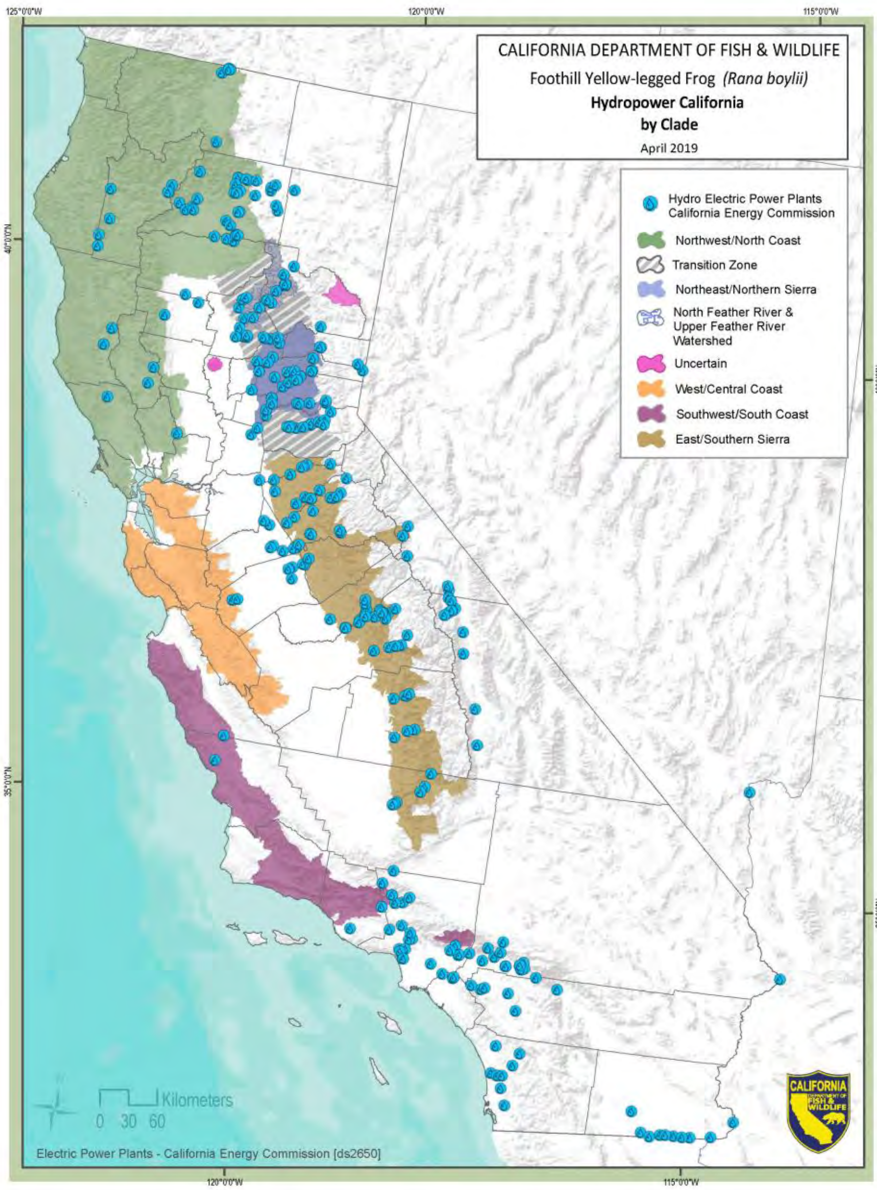


Figure 18. Locations of hydroelectric power generating dams (BIOS)

the Lewiston Dam on the Trinity River, habitat changes in a 63 km (39 mi) stretch from the dam downstream were evaluated (Lind et al. 1996). Riparian vegetation went from covering 30% of the riparian area pre-dam to 95% (Ibid.). Additionally, river bars made up 70% of the pre-dam riparian area compared to 4% post-dam, amounting to a 94% decrease in available Foothill Yellow-legged Frog breeding habitat (Ibid.).

Several features of riverine habitat below dams can decrease tadpole growth rate and other measures of fitness. As ectotherms, Foothill Yellow-legged Frogs require temperatures that support their metabolism, food conversion efficiency, growth, and development, and these temperatures may not be reached until late in the season, or not at all, when the water released is colder than their lower thermal limit (Kupferberg et al. 2011a, Catenazzi and Kupferberg 2013, Wheeler et al. 2014). Colder temperatures and higher flows reduce time spent feeding and efficiency at food assimilation, resulting in slower growth and development (Kupferberg et al. 2011a,b; Catenazzi and Kupferberg 2018). Large bed-scouring winter floods promote greater *Cladophora glomerate* blooms, the filamentous green alga that dominates primary producer biomass during the tadpole rearing season (Power et al. 2008, Kupferberg et al. 2011a). The period of most rapid tadpole growth often coincides with blooms of highly nutritious and more easily assimilated epiphytic diatoms, so reduced flows can have food-web impacts on tadpole growth and survival (Power et al. 2008, Kupferberg et al. 2011a, Catenazzi and Kupferberg 2018). In addition, colder temperatures and fluctuating summer flows, such as those released for hydroelectric power generation, can reduce the amount of algae available for grazing and can change the algal assemblage to one dominated by mucilaginous stalked diatoms like *Didymosphenia geminate* that have low nutritional value (Spring Rivers Ecological Sciences 2003, Kupferberg et al 2011a, Furey et al. 2014). Altered temperatures, flows, and food quality can contribute to slower growth and development, longer time to metamorphosis, smaller size at metamorphosis, and reduced body condition, which adversely impact fitness (Kupferberg et al. 2011b, Catenazzi and Kupferberg 2018).

As discussed in more detail in the Population Structure and Genetic Diversity section, both are strongly affected by river regulation (Peek 2011, 2018; Stillwater Sciences 2012). Foothill Yellow-legged Frogs primarily use watercourses as movement corridors, so the reservoirs created behind dams are often uninhabitable and represent barriers to gene flow (Bourque 2008; Peek 2011, 2018). This decreased connectivity can lead to loss of genetic diversity, inducing a species' ability to adapt to changing conditions (Palstra and Ruzzante 2008).

Decreased winter discharge below dams facilitates establishment and expansion of invasive bullfrogs, whose tadpoles require overwintering and are not well-adapted to flooding events (Lind et al. 1996, Doubledee et al. 2003). Where they occur, bullfrogs tend to dominate areas more altered by dam operations than less impaired areas that support a higher proportion of native species (Moyle 1973, Fuller et al. 2011). In addition to downstream effects, the reservoirs created behind dams directly destroy lotic (flowing) Foothill Yellow-legged Frog habitat, typically do not retain natural riparian communities due to fluctuating water levels, are often managed for human activities not compatible with the species' needs, and act as a source of introduced species upstream and downstream (Brode and Bury 1984, PG&E 2018). Moyle and Randall (1998) identified characteristics of sites with low native biodiversity in the Sierra Nevada foothills; they were often drainages that had been dammed and

diverted in lower- to middle-elevations and dominated by introduced fishes and bullfrogs. Even small-scale operations can have significant effects. Some farming operations divert water during periods of high flows and store it in small impoundments for use during low flow-high need times; these ponds can serve as sources for introduced species like bullfrogs to spread into areas where the habitat would otherwise be unsuitable (Kupferberg 1996b).

The mechanisms described above result in the widespread pattern of greater Foothill Yellow-legged Frog density in unregulated rivers and in reaches far enough downstream of a dam to experience minimal effects from it (Lind et al. 1996, Kupferberg 1996a, Bobzien and DiDonato 2007, Peek 2011). Abundance in unregulated rivers averages five times greater than population abundance downstream of large dams (Kupferberg et al. 2012). Figure 19 depicts a comprehensive collection of egg mass density data where at least four years of surveys have been undertaken, showing much lower abundance in regulated (S. Kupferberg pers. comm. 2019). In California, Foothill Yellow-legged Frog presence is associated with an absence of dams or with only small dams far upstream (Lind 2005, Kupferberg et al. 2012). Hydroelectric power generation from Sierra Nevada rivers accounts for nearly half its statewide production and about 9% of all electrical power used in California (Dettinger et al. 2018). Every major stream below 600 m (1968 ft) in the Sierra Nevada has at least one large reservoir (≥ 0.12 km^3 [100,000 ac-ft]), and many have multiple medium and small ones (Hayes et al. 2016). Because of this, Catenazzi and Kupferberg (2017) posit that the dam-effect on Foothill Yellow-legged Frog populations is likely greater in the Sierra Nevada than the Coast Range because dams are more often constructed in a series along a river in the former and spaced close enough together such that suitable breeding temperatures may never occur in the intervening reaches.

Pathogens and Parasites

Perhaps the most widely recognized amphibian disease is chytridiomycosis, which is caused by the fungal pathogen *Batrachochytrium dendroabatidis* (Bd). Implicated in the decline of over 500 amphibian species, including 90 presumed extinctions, it represents the greatest recorded loss of biodiversity attributable to a disease (Scheele et al. 2019). The global trade in American Bullfrogs (primarily for food) is connected to the disease's spread because the species can persist with low-level Bd infections without developing chytridiomycosis (Yap et al. 2018). Previous studies suggested Foothill Yellow-legged Frogs may not be susceptible to Bd-associated mass mortality; skin peptides strongly inhibited growth of the fungus in the lab, and the only detectable difference between Bd+ and Bd- juvenile Foothill Yellow-legged Frogs was slower growth (Davidson et al. 2007). At Pinnacles National Park in 2006, 18% of post-metamorphic Foothill Yellow-legged Frogs tested positive for Bd; all were asymptomatic and at least one Bd+ Foothill Yellow-legged Frog subsequently tested negative, demonstrating an ability to shed the fungus (Lowe 2009). However, recent studies have found historical evidence of Bd contributing to the extirpation of Foothill Yellow-legged Frogs in southern California, an acute die-off in 2013 in the Alameda Creek watershed, and another in 2018 in Coyote Creek (Adams et al. 2017a,b; Kupferberg and Catenazzi 2019). Evaluation of museum specimens indicates lower Bd prevalence (proportion of individuals infected) in Foothill Yellow-legged Frogs than most other co-occurring amphibians in southern California in the first part of the 20th century, but it spiked in the 1970s just prior to the last observation of an individual in 1977 (Adams et al. 2017b). Two museum specimens collected in 1966,

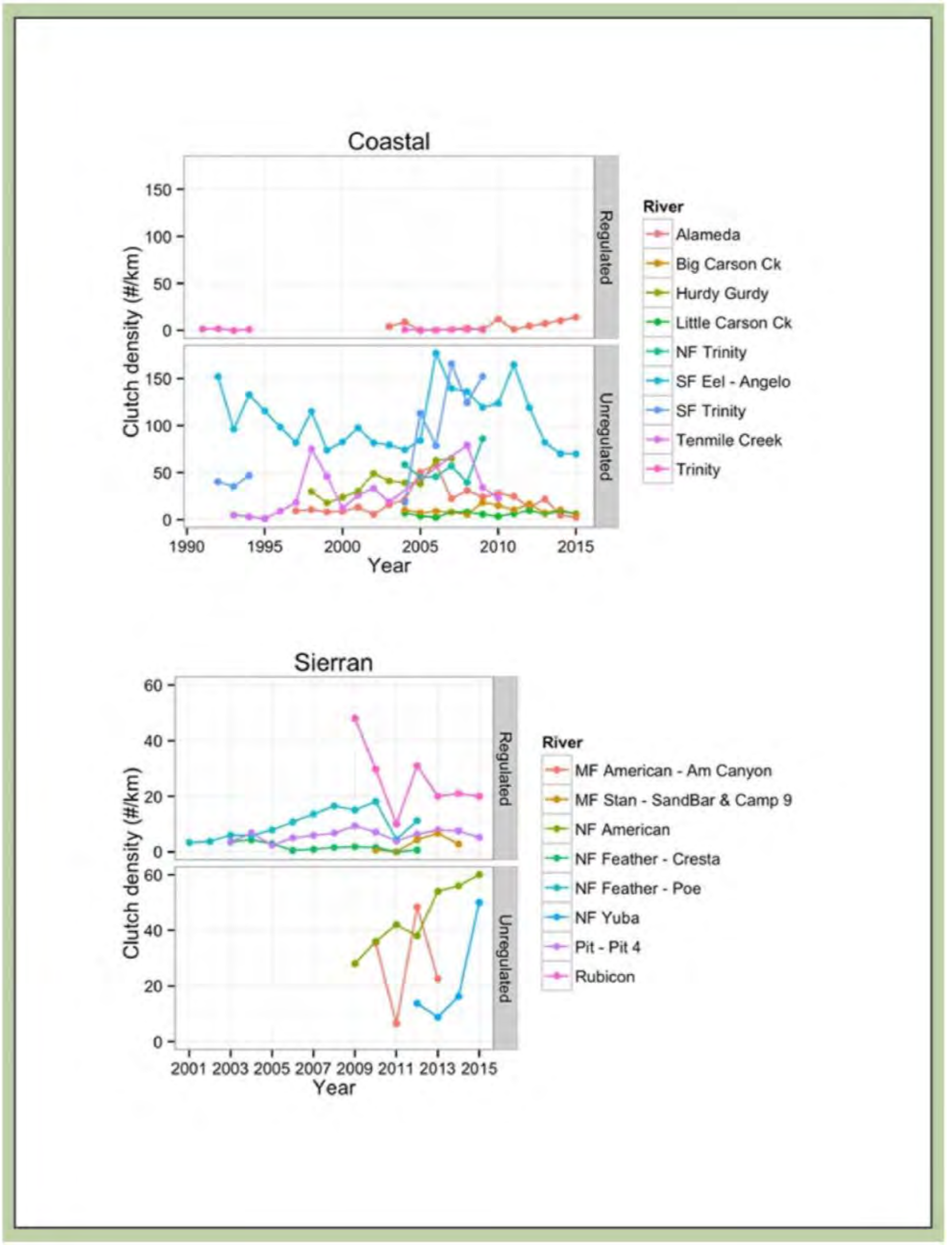


Figure 19. Foothill Yellow-legged Frog Egg mass density estimates along the coast from 1990-2015 and the Sierra Nevada from 2001-2015 from multiple studies compiled by S. Kupferberg (2019)

one from Santa Cruz County and the other from Alameda County, provide the earliest evidence of Bd in Foothill Yellow-legged Frogs in central California (Padgett-Flohr and Hopkins 2009). In contrast to the southern California results, Foothill Yellow-legged Frogs possessed the highest Bd prevalence among all amphibians tested in coastal Humboldt County in 2013 and 2014; however, zoospore (the aquatic dispersal agent) loads were well below the presumed lethal density threshold (Ecoclub Amphibian Group et al. 2016).

In addition to bullfrogs, the native Pacific Treefrog (*Pseudacris regilla*) seems immune to the lethal effects of chytridiomycosis, and owing to its broad ecological tolerances, more terrestrial lifestyle, and relatively large home range size and dispersal ability, the species is ubiquitous across California (Padgett-Flohr and Hopkins 2009). In a laboratory experiment, Bd-infected Pacific Treefrogs shed an average of 68 zoospores per minute, making them the prime candidate for spreading and maintaining Bd in areas where bullfrogs do not occur (Padgett-Flohr and Hopkins 2009, Reeder et al. 2012). In the wild, Pacific Treefrog populations persisted at 100% of sites in the Sierra Nevada (above 1500 m [4920 ft]) where a sympatric ranid species had been extirpated from 72% of its formerly occupied sites due to a Bd outbreak (Reeder et al. 2012). This is consistent with the results of a model that incorporated Bd habitat suitability, host availability, and invasion history in North America, which concluded west coast mountain ranges were at the greatest risk from the disease (Yap et al. 2018).

Several other pathogens and parasites have been encountered with Foothill Yellow-legged Frogs, but none have been ascribed to large-scale mortality events. Another fungus, a water mold (*Saprolegnia* sp.) carried by fish, is an important factor in amphibian embryo mortality in the Pacific Northwest (Blaustein et al. 1994, Kiesecker and Blaustein 1997). Fungal infections of Foothill Yellow-legged Frog egg masses, potentially from *Saprolegnia*, have been observed in the mainstem Trinity River (Ashton et al. 1997). *Saprolegnia* infection is more likely to occur in ponds and lakes, particularly if stocked by hatchery-raised fish into previously fishless areas and when frogs use communal oviposition sites, so it likely does not represent a major source of mortality in Foothill Yellow-legged Frogs (Blaustein et al. 1994, Kiesecker and Blaustein 1997). However, they may be more susceptible to *Saprolegnia* infection when exposed to other environmental stressors that compromise their immune defenses (Blaustein et al. 1994, Kiesecker and Blaustein 1997).

The trematode parasite *Ribeiroia ondatrae* is responsible for limb malformations in ranids (Stopper et al. 2002). *Ribeiroia ondatrae* was detected on a single Foothill Yellow-legged Frog during a study on malformations, but its morphology was normal (Kupferberg et al. 2009a). The results of the study instead linked malformations in Foothill Yellow-legged Frog tadpoles and young-of-year to the Anchor Worm (*Lernae cyprinacea*), a parasitic copepod from Eurasia (Ibid.). Prevalence of malformations was low, under 4% of the population in both years of study, but there was a pattern of infected individuals metamorphosing at a smaller size, which as previously mentioned can have implications on fitness (Ibid.). Three other species of helminths (parasitic worms) were encountered during the study (*Echinostoma* sp., *Manodistomum* sp., and *Gyrodactylus* sp.); their relative impact on their hosts is unknown, but at least one Foothill Yellow-legged Frog had 700 echinstome cysts in its kidney (Ibid.). Bursey et al. (2010) discovered 13 species of helminths in and on Foothill Yellow-legged Frogs from

Humboldt County. Most are common in anurans, and some are generalists with multiple possible hosts, but studies on their impact on Foothill Yellow-legged Frogs are lacking (Ibid.).

Introduced Species

Species not native to an area, but introduced, can alter food webs and ecosystem processes through predation, competition, hybridization, disease transmission, and habitat modification. Native species lack evolutionary history with introduced species, and early life stages of native anurans are particularly susceptible to predation by aquatic non-native species (Kats and Ferrer 2003). Because introduced species often establish in highly modified habitats, it can be difficult to differentiate between impacts from habitat degradation and the introduced species (Fisher and Shaffer 1996). However, native amphibians have been frequently found successfully reproducing in heavily altered habitats when introduced species were absent, suggesting introduced species themselves can impose an appreciable adverse effect (Ibid.). Numerous introduced species have been documented to adversely impact Foothill Yellow-legged Frogs or are suspected of doing so.

American Bullfrogs were introduced to California from the eastern U.S. around the turn of the 20th century, likely in response to overharvest of native ranids by the frog-leg industry that accompanied the Gold Rush (Jennings and Hayes 1985). Nearly 50 years ago, Moyle (1973) reported that distributions of Foothill Yellow-legged Frogs and bullfrogs in the Sierra Nevada foothills were nearly mutually exclusive. He speculated that bullfrog predation and competition may be causal factors in their disparate distributions in addition to the habitat degradation from dams and diversions that facilitated the bullfrog invasion in the first place. In a study along the South Fork Eel River and one of its tributaries, Foothill Yellow-legged Frog abundance was nearly an order of magnitude lower in reaches were bullfrogs were well established (Kupferberg 1997a). At a site in Napa Valley, after bullfrogs were eradicated, Foothill Yellow-legged Frogs, among other native species, recolonized the area (J. Alvarez pers. comm. 2018). In a mesocosm experiment, Foothill Yellow-legged Frog survival in control enclosures measured half that of enclosures containing bullfrog and Foothill Yellow-legged Frog tadpoles, and they weighed approximately one-quarter lighter at metamorphosis (Kupferberg 1997a). The mechanism for these declines appeared to be the reduction of high quality algae by bullfrog tadpole grazing, as opposed to any behavioral or chemical interference (Ibid.). Adult bullfrogs, which can get very large (9.0-15.2 cm [3.5-6.0 in]), also directly consume Foothill Yellow-legged Frogs, including adults (Moyle 1973, Crayon 1998, Powell et al. 2016). Silver (2017) noted that she never heard Foothill Yellow-legged Frogs calling in areas with bullfrogs, which has implications for breeding success; she speculated the lack of vocalizations may have been a predator avoidance strategy.

As discussed briefly in the Pathogens and Parasites section, American Bullfrogs act as reservoirs and vectors of the lethal chytrid fungus. In museum specimens from both southern and central California, Bd was detected in bullfrogs before it was detected in Foothill Yellow-legged Frogs in the same area (Padgett-Flohr and Hopkins 2009, Adams et al. 2017b). During a die-off from chytridiomycosis that commenced in 2013, Bd prevalence and load in Foothill Yellow-legged Frogs was positively predicted by bullfrog presence (Adams et al. 2017a). A similar die-off in 2018 from a nearby county appears to be related to transmission by bullfrogs as well (Kupferberg and Catenazzi 2019). In addition, male Foothill

Yellow-legged Frogs have been observed amplexing female bullfrogs, which may not only constitute wasted reproductive effort but could serve to increase their likelihood of contracting Bd (Lind et al. 2003a). In fact, adult males were more likely to be infected with Bd than females or juveniles during the recent die-off in Alameda Creek (Adams et al. 2017a). African Clawed Frogs (*Xenopus laevis*) have also been implicated in the spread of Bd in California because like bullfrogs, they are asymptomatic carriers (Padgett-Flohr and Hopkins 2009). However, African Clawed-Frog distribution only minimally overlaps with the Foothill Yellow-legged Frog's range unlike the widespread bullfrog (Stebbins and McGuinness 2012).

Hayes and Jennings (1986) observed a negative association between the abundance of introduced fish and Foothill Yellow-legged Frogs. Rainbow trout (*Onchorynchus mykiss*) and green sunfish (*Lepomis cyanellus*) are suspected of destroying egg masses (Van Wagner 1996). Bluegill sunfishes (*L. macrochirus*) are likely predators; in captivity when offered eggs and tadpoles of two ranid species, they consumed both life stages but a significantly greater number of tadpoles (Werschkul and Christensen 1977). Common hatchery-stocked fish like brook (*Salvelinus fontinalis*) and rainbow trout commonly carry of *Saprolegnia* (Blaustein et al. 1994). In addition, presence of non-native fish can facilitate bullfrog invasions by reducing the density of macroinvertebrates that prey on their tadpoles (Adams et al. 2003). Foothill Yellow-legged Frog tadpoles raised from eggs from sites with and without smallmouth bass (*Micropterus dolomieu*) did not differ in their responses to exposure to the non-native, predatory bass and a native, non-predatory fish (Paoletti et al. 2011). This result suggests that Foothill Yellow-legged Frogs have not yet evolved a recognition of bass as a threat, which makes them more vulnerable to predation (Ibid.).

Introduced into several areas within the Coast Range and Sierra Nevada, signal crayfish have been recorded preying on Foothill Yellow-legged Frog egg masses and are suspected of preying on their tadpoles based on observations of tail injuries that looked like scissor snips (Riegel 1959, Wiseman et al. 2005). The introduced red swamp crayfish (*Procambarus clarkii*) likely also preys on Foothill Yellow-legged Frogs. Because Foothill Yellow-legged Frogs evolved with native crayfish in northern California, individuals from those areas may more effectively avoid crayfish predation than in other parts of the state where they are not native (Riegel 1959, USFWS 1998, Kats and Ferrer 2003). The Foothill Yellow-legged Frog's naivety to crayfish was demonstrated in a study that showed they did not change behavior when exposed to signal crayfish chemical cues, but once the crayfish was released and consuming Foothill Yellow-legged Frog tadpoles, the survivors, likely reacting to chemical cues from dead tadpoles, did respond (Kerby and Sih 2015).

Sedimentation

Several anthropogenic activities, some of which are described in greater detail below, can artificially increase sedimentation into waterways occupied by Foothill Yellow-legged Frogs and adversely impact biodiversity (Moyle and Randall 1998). These activities include but are not limited to mining, agriculture, overgrazing, timber harvest, and poorly constructed roads (Ibid.). Increased fine sediments can substantially degrade Foothill Yellow-legged Frog habitat quality. Heightened turbidity decreases light penetration that phytoplankton and other aquatic plants require for photosynthesis (Cordone and Kelley

1961). When silt particles fall out of the water column, they can destroy algae by covering the bottom of the stream (Ibid.). Algae are not only important for Foothill Yellow-legged Frog tadpoles as forage but also oxygen production (Ibid.). Sedimentation may impede attachment of egg masses to substrate (Ashton et al. 1997). The effect of silt accumulation on embryonic development is unknown, but it does make them less visible, which could decrease predation risk (Fellers 2005). Fine sediments can fill interstitial spaces between rocks that tadpoles use for shelter from high velocity flows and cover from predators and that serve as sources for aquatic invertebrate prey for post-metamorphic Foothill Yellow-legged Frogs (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b).

Mining

Current mining practices, as well as legacy effects from historical mining operations, may adversely impact Foothill Yellow-legged Frogs through contaminants, direct mortality, habitat destruction and degradation, and behavioral disruption. While mercury in streams can result from atmospheric deposition, storm-induced runoff of naturally occurring mercury, agricultural runoff, and geothermal springs, runoff from historical mine sites mobilizes a significant amount of mercury (Foe and Croyle 1998, Alpers et al. 2005, Hothem et al. 2010). Beginning in the mid-1800s, extensive mining occurred in the Coast Range to supply mercury for gold mining in the Sierra Nevada, causing widespread contamination of both mountain ranges and the rivers in the Central Valley (Foe and Croyle 1998). Studies on Foothill Yellow-legged Frog tissues collected from the Cache Creek (Coast Ranges) and Greenhorn Creek (Sierra Nevada) watersheds revealed mercury bioaccumulation concentrations as high as 1.7 and 0.3 μg/g (ppm), respectively (Alpers et al. 2005, Hothem et al. 2010). For context, the U.S. Environmental Protection Agency's mercury criterion for issuance of health advisories for fish consumption is 0.3 μg/g; concentrations exceeded this threshold in Foothill Yellow-legged Frog tissues at 62% of sampling sites in the Cache Creek watershed (Hothem et al. 2010). Bioaccumulation of this powerful neurotoxin can cause deleterious impacts on amphibians including inhibited growth, decreased survival to metamorphosis, increased malformations, impaired reproduction, and other sublethal effects (Zillioux et al. 1993, Unrine et al. 2004). In a study measuring Sierra Nevada watershed health, Moyle and Randall (1998) reportedly found very low biodiversity in streams that were heavily polluted by acidic water leaching from historical mines. Acidic drainage measured as low as 3.4 pH from some mined areas in the northern Sierra Nevada (Alpers et al. 2005).

Widespread suction dredging for gold occurred in the Foothill Yellow-legged Frog's California range until enactment of a moratorium on issuing permits in 2009 (Hayes et al. 2016). Suction dredging vacuums up the contents of the streambed, passes them through a sluice box to separate the gold, and then deposits the tailings on the other side of the box (Harvey and Lisle 1998). While most habitat disturbance is localized and minor, it can be especially detrimental if it degrades or destroys breeding and rearing habitat through direct disturbance or sedimentation (Ibid.). In addition, this activity can lead to direct mortality of early life stages through entrainment, and those eggs and tadpoles that do survive passing through the suction dredge may experience greater mortality due to subsequent unfavorable physiochemical conditions and possible increased predation risk (Ibid.). Suction dredging can also reduce the availability of invertebrate prey, although this impact is typically short-lived (Ibid.). Suction dredging alters stream morphology, and relict tailing ponds can serve as breeding habitat for bullfrogs in areas

that would not normally support them (Fuller et al. 2011). However, in some areas these mining holes have reportedly benefited Foothill Yellow-legged Frogs by creating cool persistent pools that adult females appeared to prefer at one Sierra Nevada site (Van Wagner 1996). Senate Bill 637 (2015) directs the Department to work with the State Water Resources Control Board (SWRCB) to develop a statewide water quality permit that would authorize the use of vacuum or suction dredge equipment in California under conditions set forth by the two agencies. SWRCB staff, in coordination with Department staff, are in the process of collecting additional information to inform the next steps that will be taken by the SWRCB (SWRCB 2019).

Instream aggregate (gravel) mining continues today and can have similar impacts to suction dredge mining by removing, processing, and relocating stream substrates (Olson and Davis 2009). This type of mining typically removes bars used as Foothill Yellow-legged Frog breeding habitat and reduces habitat heterogeneity by creating flat wide channels (Kupferberg 1996a). Typically when listed salmonids are present, mining must be conducted above the wetted edge, but this practice can create perennial off-channel bullfrog breeding ponds (M. van Hattem pers. comm. 2018).

Agriculture

Direct loss of Foothill Yellow-legged Frog habitat from wildland conversion to agriculture is rare because the typically rocky riparian areas they inhabit are usually not conducive to farming, but removal of riparian vegetation directly adjacent to streams for agriculture is more common and widespread. The U.S. Department of Agriculture classifies 3.9 million ha (9.6 million ac) in California as cropland, which amounts to less than 10% of the state's land area, and 70% of this occurs in the Central Valley between Redding and Bakersfield (Martin et al. 2018). In addition, several indirect impacts can adversely affect Foothill Yellow-legged Frogs at substantial distances from agricultural operations such as effects from runoff (sediments and agrochemicals), drift and deposition of airborne pollutants, water diversions, and creation of novel habitats like impoundments that facilitate spread of detrimental non-native species. As sedimentation and introduced species impacts were previously discussed, this section instead focuses on the other possible adverse impacts.

Agrochemicals

Many species of amphibians, particularly ranids, have experienced declines throughout California, but the most dramatic declines have occurred in the Sierra Nevada east of the San Joaquin Valley where 60% of the total pesticide usage in the state was sprayed (Sparling et al. 2001). Agrochemicals applied to crops in the Central Valley can volatilize and travel in the atmosphere and deposit in higher elevations (LeNoir et al. 1999). Pesticide concentrations diminish as elevations increase in the lower foothills but change little from 533 to 1,920 m (1,750-6,300 ft), which coincides with the Foothill Yellow-legged Frog's elevational range (Ibid). Foothill Yellow-legged Frog absence at historically occupied sites in California significantly correlated with agricultural land use within 5 km (3 mi), and a positive relationship exists between Foothill Yellow-legged Frog declines and the amount of upwind agriculture, suggesting airborne agrochemicals may be a contributing factor (Figure 20; Davidson et al. 2002). Cholinesterase-inhibitors (most organophosphates and carbamates), which disrupt nerve impulse transmission, were

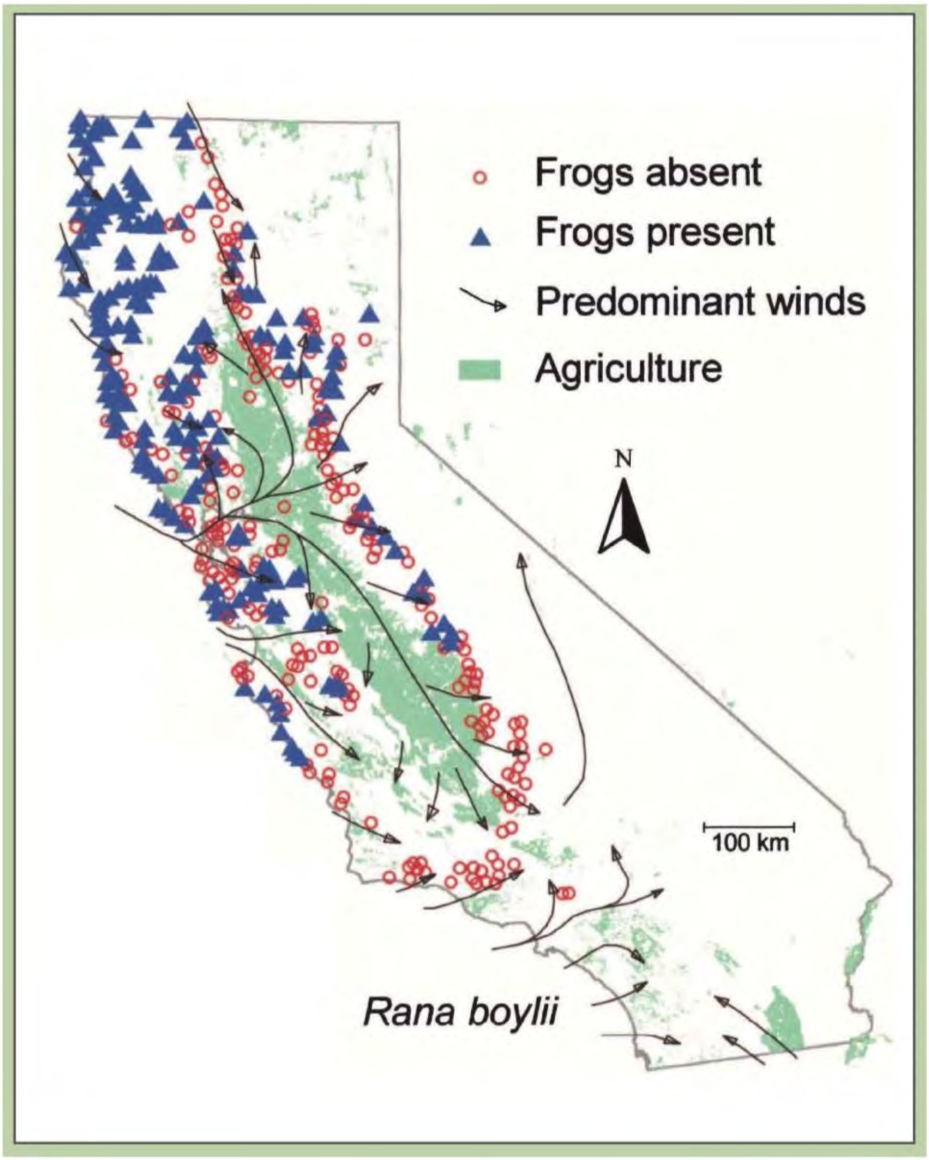


Figure 20. Relationship of Foothill Yellow-legged Frog occupancy to agriculture from Davidson et al. (2002)

more strongly associated with population declines than other pesticide types (Davidson 2004). Olson and Davis (2009) and Lind (2005) also reported a negative correlation between Foothill Yellow-legged Frog presence and proximity and quantity of nearby agriculture in Oregon and across the species' entire range, respectively.

Lethal and sublethal effects of agrochemicals on amphibians can take two general forms: direct toxicity and food-web effects. Sublethal doses of agrochemicals can interact with other environmental stressors to reduce fitness. Foothill Yellow-legged Frog tadpoles showed significantly greater vulnerability to the lethal and sublethal effects of carbaryl than Pacific Treefrogs (Kerby and Sih 2015). An inverse relationship exists between carbaryl concentration and Foothill Yellow-legged Frog activity, and their 72-h LC_{50} (concentration at which 50% die) measured one-fifth that of Pacific Treefrogs (Ibid.). Carbaryl slightly decreased Foothill Yellow-legged Frog development rate, but it significantly increased susceptibility to predation by signal crayfish despite nearly no mortality in the pesticide- and predator-only treatments (Ibid.). Sparling and Fellers (2009) also found Foothill Yellow-legged Frogs were significantly more sensitive to pesticides (chlorpyrifos and endosulfan in this study) than Pacific Treefrogs; their 96-hr LC_{50} was nearly five-times less than for treefrogs. Endosulfan was nearly 121 times more toxic to Foothill Yellow-legged Frogs than chlorpyrifos, and water samples from the Sierra Nevada have contained endosulfan concentrations within their lethal range and sometimes greater than the LC_{50} for the species (Ibid.). Sublethal effects included smaller body size, slower development rate, and increased time to metamorphosis (Ibid.). Sparling and Fellers (2007) determined the organophospates chlorpyrifos, malathion, and diazinon can harm Foothill Yellow-legged Frog populations, and their oxon derivatives (the resultant compounds once they begin breaking down in the body) were 10 to 100 times more toxic than their respective parental forms.

Extrapolating the results of studies on other ranids to Foothill Yellow-legged Frogs should be undertaken with caution; however, those studies can demonstrate additional potential adverse impacts of exposure to agrochemicals. Relyea (2005) discovered that Roundup®, a common herbicide, could cause rapid and widespread mortality in amphibian tadpoles via direct toxicity, and overspray at the manufacturer's recommended application concentrations would be highly lethal. Atrazine, another common herbicide, has been implicated in disrupting reproductive processes in male Northern Leopard Frogs (*Rana pipiens*) by slowing gonadal development, inducing hermaphroditism, and even oocyte (egg) growth (Hayes et al. 2003). However, recent research on sex reversal in wild populations of Green Frogs (*R. clamitans*) suggests it may be a relatively common natural process unrelated to environmental contaminants, requiring more research (Lambert et al. 2019). Malathion, a common organophosphate insecticide, that rapidly breaks down in the environment, applied at low concentrations caused a trophic cascade that resulted in reduced growth and survival of two species of ranid tadpoles (Relyea and Diecks 2008). Malathion caused a reduction in the amount of zooplankton, which resulted in a bloom of phytoplankton and an eventual decline in periphyton, an important food source for tadpoles (Ibid.). In contrast, Relyea (2005) found that some insecticides increased amphibian tadpole survival by reducing their invertebrate predators. Runoff from agricultural areas can contain fertilizers that input nutrients into streams and increase productivity, but they can also result in harmful algal blooms (Cordone and

Kelley 1961). In addition, exposure to pesticides can result in immunosuppression and reduce resistance to the parasites that cause limb malformations (Kiesecker 2002, Hayes et al. 2006).

Cannabis

An estimated 60-70% of the cannabis (*Cannabis indica* and *C. sativa*) used in the U.S. from legal and illegal sources is grown in California, and most comes from the Emerald Triangle, an area comprised of Humboldt, Mendocino, and Trinity counties (Ferguson 2019). Small-scale illegal cannabis farms have operated in this area since at least the 1960s but have expanded rapidly, particularly trespass grows on public land primarily by Mexican cartels, since the passage of the Compassionate Use Act in 1996 (Mallery 2010, Bauer et al. 2015). Like other forms of agriculture, it involves clearing the land, diverting water, and using herbicides and pesticides; however, in addition, many of these illicit operations use large quantities of fertilizers and highly toxic banned pesticides to kill anything that may threaten the crop, and they leave substantial amounts of non-biodegradable trash and human excrement (Mallery 2010, Thompson et al. 2014, Carah et al. 2015).

Measurements of environmental impacts of illegal cannabis grows have been hindered by the difficult and dangerous nature of accessing many of these sites; however, some analyses have been conducted, often using aerial images and geographic information systems (GIS). An evaluation of 54% of watersheds within and bordering Humboldt County revealed that while cannabis grow sites are generally small (< 0.5 ha [1.2 ac]) and comprised a tiny fraction of the study area (122 ha [301 ac]), they were widespread (present in 83% of watersheds) but unevenly distributed, indicating impacts are concentrated in certain watersheds (Butsic and Brenner 2016, Wang et al. 2017). The results also showed that 68% of grows were > 500 m (0.3 mi) from developed roads, 23% were located on slopes steeper than 30%, and 5% were within 100 m (328 ft) of critical habitat for threatened salmonids (Butsic and Brenner 2016). These characteristics suggest wildlands adjacent to cannabis cultivations are at heightened risk of habitat fragmentation, erosion, sedimentation, landslides, and impacts to waterways critical to imperiled species (Ibid.).

A separate analysis in the same general area estimated potentially significant impacts from water diversions alone. Cannabis requires a substantial amount of water during the growing season, so it is often cultivated near sources of perennial surface water for irrigation, commonly diverting from springs and headwater streams (Bauer et al. 2015). In the least impacted of the study watersheds, Bauer et al. (2015) calculated that diversions for cannabis cultivation could reduce the annual seven-day low flow by up to 23%, and in some of the heavily impacted watersheds, water demands for cannabis could exceed surface water availability. If not regulated carefully, cannabis cultivation could have substantial impacts on sensitive aquatic species like Foothill Yellow-legged Frogs in watersheds in which it is concentrated.

For context, cannabis cultivation was responsible for approximately 1.1% of forest cover lost within study watersheds in Humboldt County from 2000 to 2013, while timber harvest accounted for 53.3% (Wang et al. 2017). Cannabis requires approximately two times as much water per day as wine grapes, the other major irrigated crop in the region (Bauer et al. 2015). Impacts from cannabis cultivation have been observed by Foothill Yellow-legged Frog researchers working on the Trinity River and South Fork

Eel River in the form of lower flows in summer, increased egg stranding, and more algae earlier in the season in recent years (S. Kupferberg and M. Power pers. comm. 2015; D. Ashton pers. comm. 2017; S. Kupferberg, M. van Hattem, and W. Stokes pers. comm. 2017). In addition, Gonsolin (2010) reported illegal cannabis cultivations on four headwater streams that drained into his study area along Coyote Creek, three of which were occupied by Foothill Yellow-legged Frogs. The cultivators had removed vegetation adjacent to the creeks, terraced the slopes, diverted water, constructed small water impoundments, poured fertilizers directly into the impoundments, and applied herbicides and pesticides, as evidenced by leftover empty containers littering the site.

Commercial sale of cannabis for recreational use became legal in California on January 1, 2018, through passage of the Control, Regulate and Tax Adult Use of Marijuana Act (2016), and with it an environmental permitting system and habitat restoration fund was established. The number of applications for temporary licenses per watershed is depicted in Figure 21. Two of the expected outcomes of passage of this law were that the profit-margin on growing cannabis would fall to the point that it would discourage illegal trespass grows and move the bulk of the cultivation out of remote forested areas into existing agricultural areas like the Central Valley (CSOS 2016). However, until cannabis is legalized at the federal level, these results may not occur since banks are reluctant to work with growers due to federal prohibitions subjecting them to prosecution for money laundering (ABA 2019). Additional details on cannabis permitting at the state level can be found under the Existing Management section.

Vineyards

Vineyard operators historically built on-stream dams and removed almost all the riparian vegetation to make room for vines and for ease of irrigation (M. van Hattem pers. comm. 2019). They still divert a substantial amount of water for irrigation, and they build on- and off-stream impoundments that support bullfrogs (Ibid.). The acreage of land planted in wine grapes in California began rising dramatically in the 1970s and now accounts for 90% of wine produced in the U.S. (Geisseler and Horwath 2016, Alston et al. 2018). The number of wineries in California rose from approximately 330 to nearly 2,500 between 1975 and 2006; however, expansion slowed and has reversed slightly recently with 24,300 ha (60,000 ac), or 6.5% of total area planted, removed between 2015 and 2017 (Volpe et al. 2010, CDFA 2018). In 2015, 347,000 ha (857,000 ac) were planted in grapes with 70% located in the San Joaquin Valley; 66%, 21%, and 13% were planted in wine, raisin, and table grapes, respectively (Alston et al. 2018).

Expansion of wineries in the coastal counties converted natural areas such as oak woodlands and forests to vineyards (Merenlender 2000, Napa County 2010). The area of Sonoma County covered in grapes increased by 32% from 1990 to 1997, and 42% of these new vineyards were planted above 100 m (328 ft) with 25% on slopes greater than 18% (Merelender 2000). For context, only 18% of vineyards planted before 1990 occurred above 100 m (328 ft) and less than 6% on slopes greater than 18% (Ibid.). This conversion took place on approximately 773 ha (1,909 ac) of conifer and dense hardwood forest, 149 ha (367 ac) of shrubland, and 2,925 ha (7,229 ac) of oak grassland savanna (Ibid.).

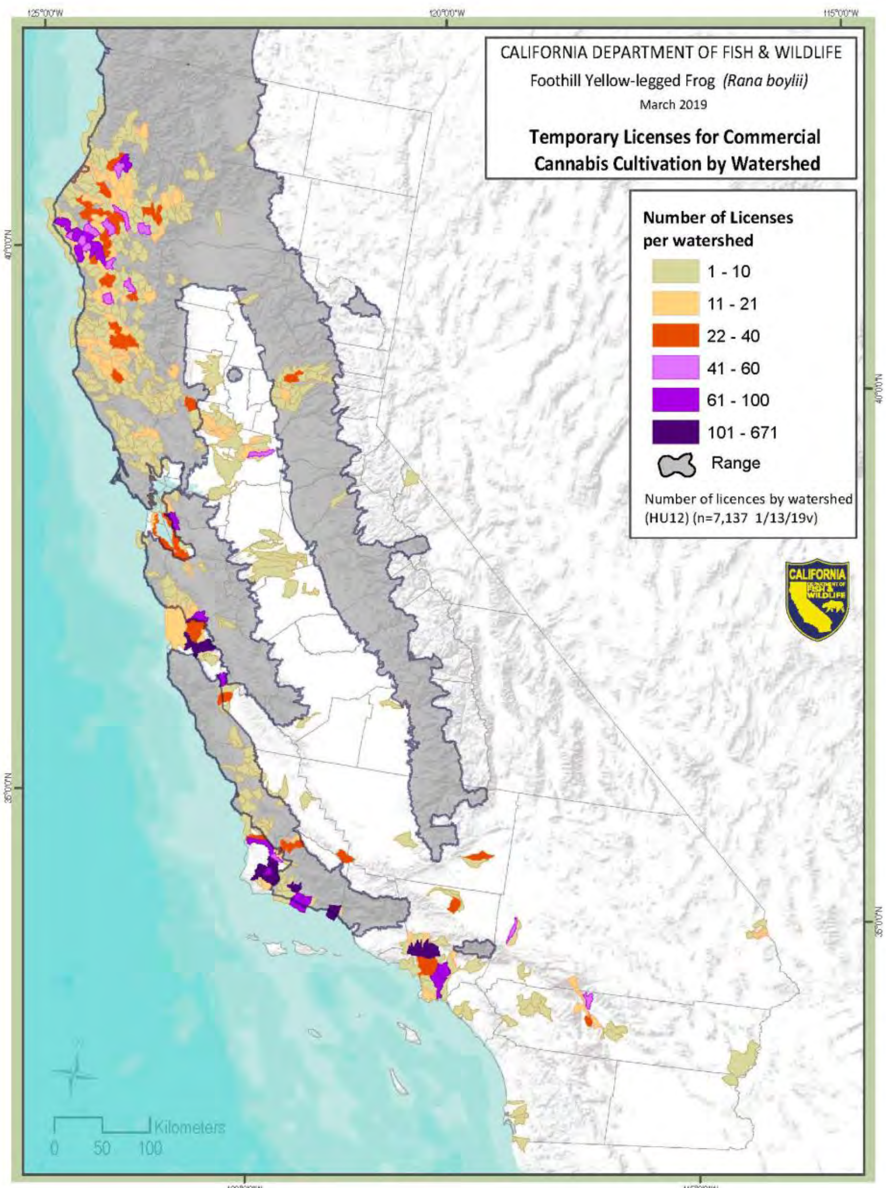


Figure 21. Cannabis cultivation temporary licenses by watershed in California (CDFA, NHD)

Recent expansion of oak woodland conversion to vineyards in Napa County was highest in its eastern hillsides (Napa County 2010). The County estimates that 1,085 and 1,240 ha (2,682-3,065 ac) of woodlands will be converted to vineyards between 2005 and 2030 (Ibid.). For context, 297 ha (733 ac) were converted from 1992 to 2003 (Ibid.). In addition, wine grapes were second only to almonds in terms of overall quantity of pesticides applied in California in 2016, but the quantity per unit area (2.9 kg/ha [2.6 lb/ac]) was 160% greater for the wine grapes (CDPR 2018). Vineyard expansion into hillsides has continued into sensitive headwater areas, and like cannabis cultivation, even small vineyards can have substantial impacts on Foothill Yellow-legged Frog habitat through sedimentation, water diversions, spread of harmful non-native species, and pesticide contamination (Merelender 2000, K. Weiss pers. comm. 2018).

Livestock Grazing

Livestock grazing can be an effective habitat management tool, including control of riparian vegetation encroachment, but overgrazing can significantly degrade the environment (Siekert et al. 1985). Cattle display a strong preference for riparian areas and have been implicated as a major source of habitat damage in the western U.S. where the adverse impacts of overgrazing on riparian vegetation are intensified by arid and semi-arid climates (Behnke and Raleigh 1978, Kauffman and Krueger 1984, Belsky et al. 1999). The severity of grazing impacts on riparian systems can be influenced by the number of animals, duration and time of year, substrate composition, and soil moisture (Benhke and Raleigh 1978, Kauffman et al. 1983, Marlow and Pogacnik 1985, Siekert et al. 1985). In addition to habitat damage, cattle can directly trample any life stage of Foothill Yellow-legged Frog.

Signs of overgrazing include impacts to the streambanks such as increased slough-offs and cave-ins that collapse undercuts used as refuge (Kauffman et al. 1983). Overgrazing reduces riparian cover, increases erosion and sedimentation, which as described above can result in silt degradation of breeding, rearing, and invertebrate food-producing areas (Cordone and Kelley 1961, Behnke and Raleigh 1978, Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). Loss of streamside and instream vegetative cover and changes to channel morphology can increase water temperatures and velocities (Behnke and Raleigh 1978). Water quality can be affected by increased turbidity and nutrient input from excrement, and seasonal water quantity can be impacted through changes to channel morphology (Belsky et al. 1999). In addition, increased nutrients and temperatures can promote blooms of harmful cyanobacteria like *Microcystis aeruginosa*, which releases a toxin when it expires that can cause liver damage to amphibians as well as other animals including humans (Bobzien and DiDonato 2007, Zhang et al. 2013).

While some recent studies indicate livestock grazing continues to damage stream and riparian ecosystems, its impact on Foothill Yellow-legged Frogs in California is unknown (Belsky et al. 1999, Hayes et al. 2016). In Oregon, the species' presence was correlated with significantly less grazing than where they were absent according to Borisenko and Hayes's 1999 report (as cited in Olson and Davis 2009). However, Fellers (2005) reported that apparently some Coast Range foothill populations occupying streams draining east into the San Joaquin Valley were doing well at the time of publication despite being heavily grazed.

Urbanization and Road Effects

Habitat conversion and fragmentation combined with modified environmental disturbance regimes can substantially jeopardize biological diversity (Tracey et al. 2018). This threat is most severe in areas like California with Mediterranean-type ecosystems that are biodiversity hot spots, fire-prone, and heavily altered by human land use (Ibid.). From 1990 to 2010, the fastest-growing land use type in the conterminous U.S. was new housing construction, which rapidly expanded the wildland-urban interface (WUI) where houses and natural vegetation meet or intermix on the landscape (Radeloff et al. 2018).

Of several variables tested, proportion of urban land use within a 5 km (3.1 mi) radius of a site was associated with Foothill Yellow-legged Frog declines (Davidson et al. 2002). Lind (2005) also found significantly less urban development nearby and upwind of sites occupied by Foothill Yellow-legged Frogs, suggesting pollutant drift may be a contributing factor. Changes in wildfires may also contribute to the species' declines; 95% of California's fires are human-caused, and wildfire issues are greatest at the WUI (Syphard et al. 2009, Radeloff et al. 2018). Population density, intermix WUI (where wildland and development intermingle as opposed to an abrupt interface), and distance to WUI explained the most variability in fire frequency (Syphard et al. 2007). In addition to wildfires, habitat loss, and fragmentation, urbanization can impact adjacent ecosystems through non-native species introduction, native predator subsidization, and disease transmission (Bar-Massada et al. 2014).

Projections show growth in California's population to 51 million people by 2060 from approximately 40 million currently (PPIC 2019). This will increase urbanization, the WUI, and habitat fragmentation. The Department of Finance projects the Inland Empire, the San Joaquin Valley, and the Sacramento metropolitan area will be the fastest-growing regions of the state over the next several decades (Ibid.). This puts the greatest pressure in areas outside of the Foothill Yellow-legged Frog's range; however, because the environmental stressors associated with urbanization can span far beyond its physical footprint, they may still adversely affect the species.

Highways are frequently recognized as barriers to dispersal that fragment habitats and populations; however, single-lane roads can pose significant risks to wildlife as well (Cook et al. 2012, Brehme et al. 2018). Foothill Yellow-legged Frogs are at risk of being killed by vehicles when roads are located near their habitat (Cook et al. 2012, Brehme et al. 2018). Fifty-six juvenile Foothill Yellow-legged Frogs were found on a road adjacent to Sulphur Creek (Mendocino County), seven of which had been struck and killed (Cook et al. 2012). When fords (naturally shallow areas) are used as vehicle crossings, they can create sedimentation and poor water quality, and in some cases, the fords are gravel or cobble bars used by Foothill Yellow-legged Frogs for breeding that could result in direct mortality (K. Blanchard pers. comm. 2018, R. Bourque pers. comm. 2018). Construction of culverts under roads to keep vehicles out of the streambed can result in varying impacts. In some cases, they can impede dispersal and create deep scoured pools that support predatory fish and frogs, but when properly constructed, they can facilitate frog movement up and down the channel with reduced road mortality (Van Wagner 1996, GANDA 2008). In areas where non-native species are not a threat, but premature drying is, pools created by culverts can provide habitat in otherwise unsuitable areas (M. Grefsrud pers. comm. 2019). An evaluation of the impact of roads on 166 native California amphibians and reptiles through direct

morality and barriers to movement concluded that Foothill Yellow-legged Frogs, at individual and population levels, were at moderate risk of road impacts in aquatic habitat but very low risk of impacts in terrestrial habitat (Brehme et al. 2018). For context, all chelonids (turtles and tortoises), 72% of snakes, 50% of anurans, 18% of lizards, and 17% of salamander species in California were ranked as having a high or very high risk of negative road impacts in the same evaluation (Ibid.).

Poorly constructed roadways near rivers and streams can result in substantial erosion and sedimentation, leading to reduced amphibian densities (Welsh and Ollivier 1998). Proximity of roads to Foothill Yellow-legged Frog habitat contributes to petrochemical runoff and poses the threat of spills (Ashton et al. 1997). A diesel spill on Hayfork Creek (Trinity County) resulted in mass mortality of Foothill Yellow-legged Frog tadpoles and partial metamorphs (Bury 1972). Roads have also been implicated in the spread of disease and may have aided in the spread of Bd in California (Adams et al. 2017b).

Frogs use auditory and visual cues to defend territories and attract mates, and some studies reveal that realistic levels of traffic noise can impede transmission and reception of these signals (Bee and Swanson 2007). Some male frogs have been observed changing the frequency of their calls to increase the distance they can be heard over traffic noise, but if females have evolved to recognize lower pitched calls as signs of superior fitness, this potential trade-off between audibility and attractiveness could have implications for reproductive success (Parris et al. 2009). In a separate study, traffic noise caused a change in male vocal sac coloration and an increase in stress hormones, which changed sexual selection processes and suppressed immunity (Troïanowski et al. 2017). Because Foothill Yellow-legged Frogs mostly call underwater and are not known to use color displays, communication cues may not be adversely affected by traffic noise, but their stress response is unknown.

Timber Harvest

Because Foothill Yellow-legged Frogs tend to remain close to the water channel (i.e., within the riparian corridor) and current timber harvest practices minimize disturbance in riparian areas for the most part, adverse effects from timber harvest are expected to be relatively low (Hayes et al. 2016, CDFW 2018b). However, some activities have a potential to negatively impact Foothill Yellow-legged Frogs or their habitat, including direct mortality and increased sedimentation during construction and decommissioning of watercourse crossings and infiltration galleries, tree felling, log hauling, and entrainment by water intakes or desiccation of eggs and tadpoles through stranding from dewatering during drafting operations (CDFW 2018b,c). In addition to impacts previously described under the Sedimentation and Road Effects section, when silt runoff into streams is accompanied by organic materials, such as logging debris, impaired water quality can result, including reduced dissolved oxygen, which is important in embryonic and tadpole development (Cordone and Kelley 1961).

Because Foothill Yellow-legged Frogs are heliotherms (i.e, they bask in the sun to raise their body temperature) and sensitive to thermal extremes, some moderate timber harvest may benefit the species (Zweifel 1955, Fellers 2005). Ashton (2002) reported 85% of his Foothill Yellow-legged Frog observations occurred in second-growth forests (37-60 years post-harvest) as opposed to late-seral forests and postulated that the availability of some open canopy areas played a major part in this

disparity. Foothill Yellow-legged Frogs are typically absent in areas with closed canopy (Welsh and Hodgson 2011). Reduced canopy also raises stream temperatures, which could improve tadpole development and promote algal and invertebrate productivity in otherwise cold streams (Olson and Davis 2009; Catenazzi and Kupferberg 2013,2017).

Recreation

Several types of recreation can adversely impact Foothill Yellow-legged Frogs, and some are more severe and widespread than others. One of the main potential factors identified by herpetologists as contributing to disappearance of Foothill Yellow-legged Frogs in southern California was increased and intensified recreation in streams (Adams et al. 2017b). The greater number of people traveling into the backcountry may have facilitated the spread Bd to these areas, and while no evidence shows stress from disturbance or other environmental pressures increases susceptibility to Bd, the stress hormone corticosterone has been implicated in immunosuppression (Hayes et al. 2003, Adams et al. 2017b).

The amount of Foothill Yellow-legged Frog habitat disturbed by off-highway motor vehicles (OHV) throughout its range in California is unknown, but its impacts can be significant, particularly in areas with small isolated populations (Kupferberg et al. 2009c, Kupferberg and Furey 2015). An example is the Carnegie State Vehicular Recreation Area (CVSRA), located in the hills southwest of Tracy in the Corral Hollow Creek watershed (Alameda and San Joaquin counties). The above-described road effects apply: sedimentation, crushing along trail crossings, and potential noise effects (Ibid.). In addition, dust suppression activities employed by CSVRA use magnesium chloride ($MgCl_2$), which has the potential to harm developing embryos and tadpoles (Karraker et al. 2008, Hopkins et al. 2013, OHMVRC 2017). Based on museum records, Foothill Yellow-legged Frogs were apparently abundant in Corral Hollow Creek, but they are extremely rare now and are already extirpated or at risk of extirpation (Kupferberg et al. 2009c, Kupferberg and Furey 2015).

Motorized and non-motorized recreational boating can also impact Foothill Yellow-legged Frogs. The impacts of jet boat traffic were investigated in Oregon; in areas with frequent use and high wakes breaking on shore, Foothill Yellow-legged Frogs were absent (Borisenko and Hayes 1999 as cited in Olson and Davis 2009). This wake action had the potential to dislodge egg masses, strand tadpoles, disrupt adult basking behavior, and erode shorelines (Ibid.). Jet boat tours and races on the Klamath River (Del Norte and Humboldt counties) may have an impact on Foothill Yellow-legged Frog use of the mainstem (M. van Hattem pers. comm. 2019). In addition, using gravel bars as launch and haul out sites for boat trailers, kayaks, or river rafts can result in direct loss of egg masses and tadpoles or damage to breeding and rearing habitat and can disrupt post-metamorphic frog behavior (Ibid.). As described above, pulse flows released for whitewater boating in the late spring and summer can result in scouring and stranding of egg masses and tadpoles (Borisenko and Hayes 1999 as cited in Olson and Davis 2009, Kupferberg et al. 2009b). In addition, the velocities that resulted in stunted growth and increased vulnerability to predation in Foothill Yellow-legged Frog tadpoles were less than the increased velocities experienced in nearshore habitats during intentional release of recreational flows for whitewater boating, as well as hydropeaking for power generation (Kupferberg et al. 2011b).

Hiking, horse-riding, camping, fishing, and swimming, particularly in sensitive breeding and rearing habitat can also adversely impact Foothill Yellow-legged Frog populations (Borisenko and Hayes 1999 in Olson and Davis 2009). Because Foothill Yellow-legged Frog breeding activity was being disturbed and egg masses were being trampled by people and dogs using Carson Falls (Marin County), the land manager established an educational program, including employing docents on weekends that remind people to stay on trails and tread lightly to try to reduce the loss of Foothill Yellow-legged Frog reproductive effort (Prado 2005). In addition, within his study site, Van Wagner (1996) reported that a property owner moved rocks that were being used as breeding habitat to create a swimming hole. The extent to which this is more than a small, local problem is unknown, but as the population of California increases, recreational pressures in Foothill Yellow-legged Frog habitat are likely to increase commensurately.

Drought

Drought is a common phenomenon in California and is characterized by lower than average precipitation. Lower precipitation in general results in less surface water, and water availability is critical for obligate stream-breeding species. Even in the absence of drought, a positive relationship exists between precipitation and latitude within the Foothill Yellow-legged Frog's range in California, and mean annual precipitation has a strong influence on Foothill Yellow-legged Frog presence at historically occupied sites (Davidson et al. 2002, Lind 2005). Figure 22 depicts the recent historical annual average precipitation across the state as well as during the most recent drought and how they differ. Southern California is normally drier than northern California, but the severity of the drought was even greater in the south.

Reduced precipitation can result in deleterious effects to Foothill Yellow-legged Frogs beyond the obvious premature drying of aquatic habitat. When stream flows recede during the summer and fall, sometimes the isolated pools that stay perennially wet are the only remaining habitat. This phenomenon concentrates aquatic species, resulting in several potentially significant adverse impacts. Stream flow volume was negatively correlated with Bd load during a recent chytridiomycosis outbreak in the Alameda Creek watershed (Adams et al. 2017a). The absence of high peak flows in winter coupled with wet years allowed bullfrogs to expand their distribution upstream, and the drought-induced low flows in the fall concentrated them with Foothill Yellow-legged Frogs in the remaining drying pools (Ibid.). This mass mortality event appeared to have been the result of a combination of drought, disease, and dam effects (Ibid.). This die-off occurred in a regulated reach that experiences heavy recreational use and presence of crayfish and bass (Ibid.). Despite these threats, the density of breeding females in this reach was greater in 2014 and 2015 than the in the unregulated reach upstream because the latter dried completely before tadpoles could metamorphose during the preceding drought years (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015).

In addition to increasing the spread of pathogens, drought-induced stream drying can increase predation and competition by introduced fish and frogs in the pools they are forced to share (Moyle 1973, Hayes and Jennings 1988, Drost and Fellers 1996). This concentration in isolated pools can also result in increased native predation as well as facilitate spread of Bd. An aggregation of six adult Foothill

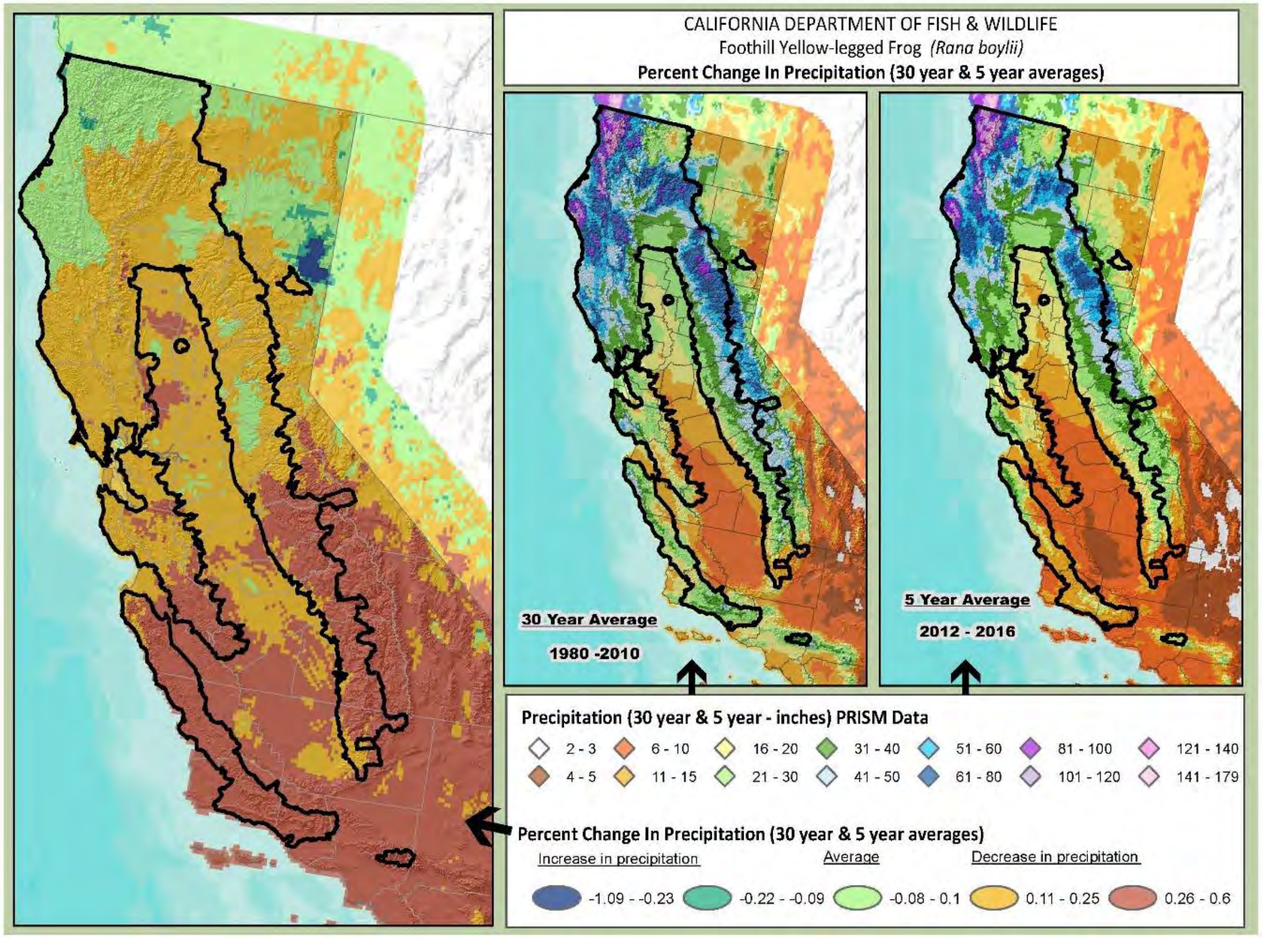


Figure 22. Change in precipitation from 30-year average and during the recent drought (PRISM)

Yellow-legged Frogs was observed perched on a rock above an isolated pool where a gartersnake was foraging on tadpoles during the summer; this close contact may reduce evaporative water loss when they are forced out of the water during high temperatures, but it can also increase disease transmission risk (Leidy et al. 2009.). Gonsolin (2010) also documented a late summer aggregation of juvenile Foothill Yellow-legged Frogs out of water during extremely high temperatures. In addition, drought-induced low flow, high water temperatures, and high densities of tadpoles were associated with outbreaks of malformation-inducing parasitic copepods (Kupferberg et al. 2009a).

Rapidly receding spring flows can result in stranding egg masses and tadpoles. However, this risk is likely less significant when it is drought-induced on an unregulated stream vs. a result of dam operations since Foothill Yellow-legged Frogs have evolved to initiate breeding earlier and shorten the breeding period in drought years (Kupferberg 1996a). If pools stay wet long enough to support metamorphosis, complete drying at the end of the season may benefit Foothill Yellow-legged Frogs if it eliminates introduced species like warm water fish and bullfrogs. Moyle (1973) noted that the only intermittent streams occupied by Foothill Yellow-legged Frogs in the Sierra Nevada foothills had no bullfrogs. At a long-term study site in upper Coyote Creek in 2015, Foothill Yellow-legged Frogs had persisted in reaches that had at least some summer water through the three preceding years of the most severe drought in over a millennium, albeit at much lower abundance than a decade before (Gonsolin 2010, Griffin and Anchokaitis 2014, J. Smith pers. comm. 2015). The population's abundance appeared to have never recovered from the 2007-2009 drought before the 2012-2016 drought began (J. Smith pers. comm. 2015). In 2016, after a relatively wet winter, Foothill Yellow-legged Frogs bred en masse, and only a single adult bullfrog was detected, an unusually low number for that area (CDWR 2016, J. Smith pers. comm. 2016). It appeared the population may rebound; however, in 2018, it experienced lethal chytridiomycosis outbreak, and like the Alameda Creek die-off probably resulted from crowding during drought, presence of bullfrogs as Bd-reservoirs and predators and competitors, and the stress associated with the combination of the two (Kupferberg and Catenazzi 2019).

Drought effects can also exacerbate other environmental stressors. During the most recent severe drought, tree mortality increased dramatically from 2014 to 2017 and reached approximately 129 million dead trees (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are more prone to severe wildfires, and they lose their carbon sequestration function while also emitting methane, which is an extremely damaging greenhouse gas (CNRA 2016). Post-wildfire storms can result in erosion of fine sediments from denuded hillsides into the stream channel (Florsheim et al. 2017). If the storms are short duration and low precipitation, as happens during droughts, their magnitude may not be sufficient to transport the material downstream, resulting in a longer temporal loss or degradation of stream habitat (Ibid.). Reduced rainfall may also infiltrate the debris leading to subsurface flows rather than the surface water Foothill Yellow-legged Frogs require (Ibid.). Extended droughts increase risk of the stream being uninhabitable or inadequate for breeding for multiple years, which would result in population-level impacts and possible extirpation (Ibid.).

Wildland Fire and Fire Management

Fire is an important element for shaping and maintaining the species composition and integrity of many California ecosystems (Syphard et al. 2007, SBFFP 2018). Prior to European settlement, an estimated 1.8 to 4.9 million ha (4.5-12 million ac) burned annually (4-11% of total area of the state), ignited both deliberately by Native Americans and through lightning strikes (Keeley 2005, SBFFP 2018). The impacts of wildland fires on Foothill Yellow-legged Frogs are poorly understood and likely vary significantly across the species' range with differences in climate, vegetation, soils, stream-order, slope, frequency, and severity (Olson and Davis 2009). Mortality from direct scorching is unlikely because Foothill Yellow-legged Frogs are highly aquatic, and most wildfires occur during the dry period of the year when the frogs are most likely to be in or near the water (Pilliod et al. 2003, Bourque 2008). Field observations support this presumption; sightings of post-metamorphic Foothill Yellow-legged Frogs immediately after fires in the northern Sierra Nevada and North Coast indicate they are not very vulnerable to the direct effects of fire (S. Kupferberg and R. Peek pers. comm. 2018). Similarly, Foothill Yellow-legged Frogs were observed two months, and again one year, after a low- to moderate-intensity fire burned an area in the southern Sierra Nevada in 2002, and the populations were extant and breeding as recently as 2017 (Lind et al. 2003b, CNDDB 2019). While water may provide a refuge during the fire, it is also possible for temperatures during a fire, or afterward due to increased solar exposure, to near or exceed a threshold resulting lethal or sublethal harm; this would likely impact embryos and tadpoles with limited dispersal abilities (Pilliod et al. 2003).

Intense fires remove overstory canopy, which provides insulation from extreme heat and cold, and woody debris that increases habitat heterogeneity (Pilliod et al. 2003, Olson and Davis 2009). If this happens frequently enough, it can permanently change the landscape. For example, frequent high-severity burning of crown fire-adapted ecosystems can prevent forest regeneration since seeds require sufficient time between fires to mature, and repeated fires can deplete the seed bank (Stephens et al. 2014). Smoke and ash change water chemistry through increased nutrient and heavy metal inputs that can reach concentrations harmful to aquatic species during the fire and for days, weeks, or years after (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Erosion rates on granitic soils, which make up a large portion of the Foothill Yellow-legged Frog's range, can be over 60 times greater in burned vs. unburned areas and can increase sedimentation for over 10 years (Megahan et al. 1995, Hayes et al. 2016). Post-fire nutrient inputs into streams could benefit Foothill Yellow-legged Frogs through increased productivity and more rapid growth and development (Pilliod et al. 2003). While the loss of leaf litter that accompanies fire alters the food web, insects are expected to recolonize rapidly, and the lack of cover could increase their vulnerability to predation by Foothill Yellow-legged Frogs (Ibid.).

Low-intensity fires likely have no adverse effect on Foothill Yellow-legged Frogs (Olson and Davis 2009). If they occur in areas with dense canopy, wildfires can improve habitat quality for Foothill Yellow-legged Frogs by reducing riparian cover, providing areas to bask, and increasing habitat heterogeneity, which is likely to outweigh any adverse effects from some fire-induced mortality (Russell et al. 1999, Olson and Davis 2009). In a preliminary analysis of threats to Foothill Yellow-legged Frogs in Oregon, proximity to stand-replacing fires was not associated with absence (Olson and Davis 2009).

Euro-American colonization of California significantly altered the pattern of periodic fires with which California's native flora and fauna evolved through fire exclusion, land use practices, and development (OEHHA 2018). Fire suppression can lead to canopy closure, which reduces habitat quality by limiting thermoregulatory opportunities (Olson and Davis 2009). In addition, fire suppression and its subsequent increase in fuel loads combined with expanding urbanization and rising temperatures have resulted in a greater likelihood of catastrophic stand-replacing fires that can significantly alter riparian systems for decades (Pilliod et al. 2003). Firebreaks, in which vegetation is cleared from a swath of land, can result in similar impacts to roads and road construction (Ibid.). Fire suppression can also include bulldozing within streams to create temporary reservoirs for pumping water, which can cause more damage than the fire itself to Foothill Yellow-legged Frogs in some cases (S. Kupferberg and R. Peek pers. comm. 2018). In addition, fire suppression practices can involve applying hundreds of tons of ammonia-based fire retardants and surfactant-based fire suppressant foams from air tankers and fire engines (Pilliod et al. 2003). Some of these chemicals are highly toxic to some anurans (Little and Calfee 2000).

Fire suppression has evolved into fire management with a greater understanding of its importance in ecosystem health (Keeley and Syphard 2016). Several strategies are employed including prescribed burns, mechanical fuels reduction, and allowing some fires to burn instead of necessarily extinguishing them (Pilliod et al. 2003). Like wildfires themselves, fire management strategies have the potential to benefit or harm Foothill Yellow-legged Frogs. Prescribed fires and mechanical fuels removal lessen the likelihood of catastrophic wildfires, but they can also result in loss of riparian vegetation, excessive sedimentation, and increased water temperatures (Ibid.). Salvage logging after a fire may result in similar impacts to timber harvest but with higher rates of erosion and sedimentation (Ibid.). A balanced approach to wildland fires is likely to have the greatest beneficial impact on species and ecosystem health (Stephens et al. 2012).

Floods and Landslides

As previously described, Foothill Yellow-legged Frog persistence is highly sensitive to early life stage mortality (Kupferberg et al. 2009c). While aseasonal dam releases are a major source of egg mass and tadpole scouring, storm-driven floods are also capable of it (Ashton et al. 1997). Van Wagner (1996) concluded that the high discharge associated with heavy rainfall could account for a significant source of mortality in post-metamorphic Foothill Yellow-legged Frogs as well as eggs and tadpoles; he observed two adult females and several juveniles swept downstream with fatal injuries post-flooding. Severe flooding, specifically two 500-year flood events in early 1969 in Evey Canyon (Los Angeles County), resulted in massive riparian habitat destruction (Sweet 1983). Prior to the floods, Foothill Yellow-legged Frogs were widespread and common, but only four subsequent sightings were documented between 1970 and 1974 and none since (Sweet 1983, Adams 2017b). Sweet (1983) speculates that because Foothill Yellow-legged Frogs overwinter in the streambed in that area, the floods may have reduced the population's abundance below an extinction threshold. Four other herpetologists interviewed about Foothill Yellow-legged Frog extirpations in southern California listed severe flooding as a likely cause (Adams et al. 2017b).

As mentioned above, landslides are a frequent consequence of post-fire rainstorms and can result in lasting impacts to stream morphology, water quality, and Foothill Yellow-legged Frog populations. On the other hand, Olson and Davis (2009) suggest that periodic landslides can have beneficial effects by transporting woody debris into the stream that can increase habitat complexity and by replacing sediments that are typically washed downstream over time. Whether a landslide is detrimental or beneficial is likely heavily influenced by amount of precipitation and the underlying system. As previously described, too little precipitation could lead to prolonged loss of habitat through failure to transport material downstream, and too much precipitation can result in large-scale habitat destruction and direct mortality.

Climate Change

Global climate change threatens biodiversity and may lead to increased frequency and severity of drought, wildfires, flooding, and landslides (Williams et al. 2008, Keely and Syphard 2016). Data show a consistent trend of warming temperatures in California and globally; 2014 was the warmest year on record, followed by 2015, 2017, and 2016 (OEHHA 2018). Climate model projections for annual temperature in California in the 21st century range from 1.5 to 4.5°C (2.7-8.1°F) greater than the 1961-1990 mean (Cayan et al. 2008). Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation, and increasingly dry conditions in California resulting from increased evaporative water loss primarily due to rising temperatures (Cayan et al. 2005, Williams et al. 2015, OEHHA 2018). Precipitation variability and proportion of dry years were negatively associated with Foothill Yellow-legged Frog presence in a range-wide analysis (Lind 2005). In addition, low precipitation intensified the adverse effects of dams on the species (Ibid.).

California recently experienced the longest drought since the U.S. Drought Monitor began reporting in 2000 (NIDIS 2019). Until March 5, 2019, California experienced drought effects in at least a portion of the state for 376 consecutive weeks; the most intense period occurred during the week of October 28, 2014 when D4 (the most severe drought category) affected 58.4% of California's land area (Figure 23; NIDIS 2019). A recent modeling effort using data on historical droughts, including the Medieval megadrought between 1100 and 1300 CE, indicates the mean state of drought from 2050 to 2099 in California will likely exceed the Medieval-era drought, under both high and moderate greenhouse gas emissions models (Cook et al. 2015). The probability of a multidecadal (35 yr) drought occurring during the late 21st century is greater than 80% in all models used by Cook et al. (2015). If correct, this would represent a climatic shift that not only falls outside of contemporary variability in aridity but would also be unprecedented in the past millennium (Ibid.).

As a result of increasing temperatures, a decreasing proportion of precipitation falls as snow, resulting in more runoff from rainfall during the winter and a shallower snowpack that melts more rapidly (Stewart 2009). A combination of reduced seasonal snow accumulation and earlier streamflow timing significantly reduces surface water storage capacity and increases the risk for winter and spring floods, which may require additional and taller dams and result in alterations to hydroelectric power generation flow regimes (Cayan et al. 2005, Knowles et al. 2006, Stewart 2009). The reduction in snowmelt volume

is expected to impact the northern Sierra (Feather, Yuba, and American River watersheds) to a greater extent than the southern portion (Young et al. 2009). The earlier shift in peak snowmelt timing is predicted to exceed four to six weeks across the entire Sierra Nevada depending on the amount of warming that occurs this century (Ibid.). In addition, the snow water equivalent is predicted to significantly decline by 2070-2099 over the 1961-1990 average in the Trinity, Sacramento, and San Joaquin drainages from -32% to -79%, and effectively no snow is expected to fall below 1000 m (3280 ft) in the high emissions/sensitive model (Cayan et al. 2008).

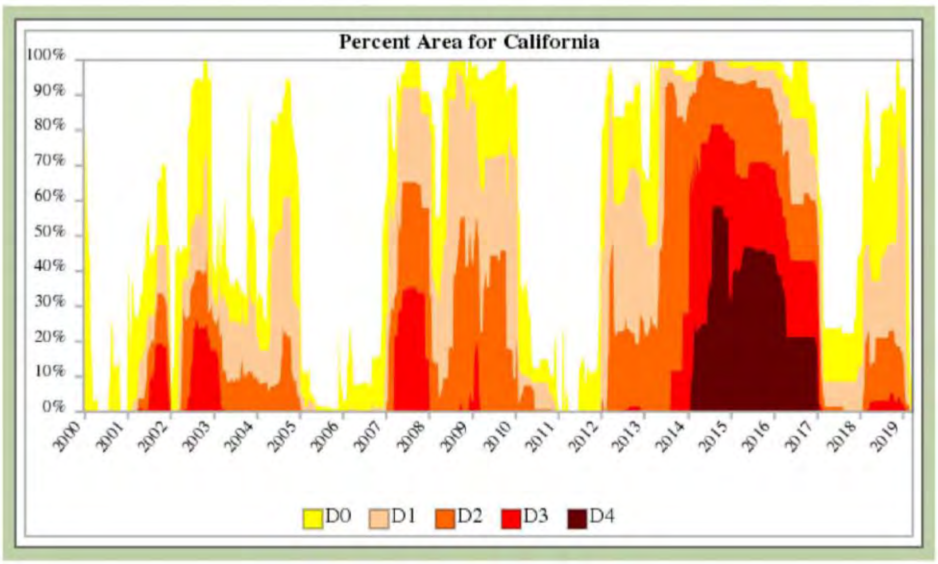


Figure 23. Palmer Hydrological Drought Indices 2000-present (NIDIS)

The earlier shift of snowmelt and lower water content will result in lower summer flows, which will intensify the competition for water among residential, agricultural, industrial, and environmental needs (Field et al. 1999, Cook et al. 2015). In unregulated systems, as long as water is present through late summer, an earlier hydrograph recession that triggers Foothill Yellow-legged Frog breeding could result in a longer time to grow larger prior to metamorphosis, which improves probability of survival (Yarnell et al. 2010, Kupferberg 2011b). However, if duration from peak to base flow shortens, it can result in increased sedimentation and reduced habitat complexity in addition to stranding (Yarnell et al. 2010).

Fire frequency relates to temperature, fuel loads, and fuel moisture (CCSP 2008). Therefore, increasing periods of drought combined with extreme heat and low humidity that stress or kill trees and other vegetation create ideal conditions for wildland fires (Ibid). Not surprisingly, the area burned by wildland fires over the western U.S. increased since 1950 but rose rapidly in the mid-1980s (Westerling et al. 2006, OEHHA 2018). As temperatures warmed and snow melted earlier, large-wildfire frequency and duration increased, and wildfire seasons lengthened (Westerling et al. 2006, OEHHA 2018).

In California, latitude inversely correlates with temperature and annual area burned, but the climate-fire relationship is substantially different across the state, and future wildfire regimes are difficult to predict (Keeley and Syphard 2016). For example, the relationship between spring and summer temperature and area burned in the Sierra Nevada is highly significant but not in southern California (Ibid.). Climate has a greater influence on fire regimes in mesic than arid environments, and the most influential climatological factor (e.g., precipitation, temperature, season, or their interactions) shifts over time (Ibid.). Nine of the 10 largest fires in California since 1932 have occurred in the past 20 years, 4 within the past 2 years (Figure 24; CAL FIRE 2019). However, it is possible this trend will not continue; climate- and wildfire-induced changes in vegetation could reduce wildfire severity in the future (Parks et al. 2016).

Wildfires themselves can accelerate the effects of climate change. Wildfires emit short-lived climate pollutants like black carbon (soot) and methane that are tens to thousands of times greater than carbon dioxide (the main focus of greenhouse gas reduction) in terms of warming effect and are responsible for 40% or more of global warming to date (CNRA 2016). Healthy forests can sequester large amounts of carbon from the atmosphere, but recently carbon emissions from wildfires have exceeded their uptake by vegetation in California (Ackerly et al. 2018).

With increased variability and changes in precipitation type, magnitude, and timing comes more variable and extreme stream flows (Mallakpour et al. 2018). Models for stream flow in California project higher high flows, lower low flows, wetter rainy seasons, and drier dry seasons (Ibid.). The projected water cycle extremes are related to strengthening El Niño and La Niña events, and both severe flooding and intense drought are predicted to increase by at least 50% by the end of the century (Yoon et al. 2015). These changes increase the likelihood of Foothill Yellow-legged Frog egg mass and tadpole scouring and stranding, even in unregulated rivers.

A species' vulnerability to climate change is a function of its sensitivity to climate change effects, its exposure to them, and its ability to adapt its behaviors to survive with them (Dawson et al. 2011). Myriad examples exist of species shifting their geographical distribution toward the poles and to higher elevations and changing their growth and reproduction with increases in temperature over time (Parmesan and Yohe 2003). However, in many places, fragmentation of suitable habitat by anthropogenic barriers (e.g., urbanization, agriculture, and reservoirs) limits a species' ability to shift its range (Pounds et al. 2007). The proportion of sites historically occupied by Foothill Yellow-legged Frogs that are now extirpated increases significantly on a north-to-south latitudinal gradient and at drier sites within California, suggesting climate change may contribute to the spatial pattern of the species' declines (Davidson et al. 2002).

An analysis of the climate change sensitivity of 195 species of plants and animals in northwestern North America revealed that, as a group, amphibians and reptiles were estimated to be the most sensitive (Case et al. 2015). Nevertheless, examples exist of amphibians adjusting their breeding behaviors (e.g., calling and migrating to breeding sites) to occur earlier in the year as global warming increases (Beebee 1995, Gibbs and Breisch 2001). Because of the rapid change in temperature, Beebee (1995) posits these are examples of behavioral and physiological plasticity rather than natural selection. However, for

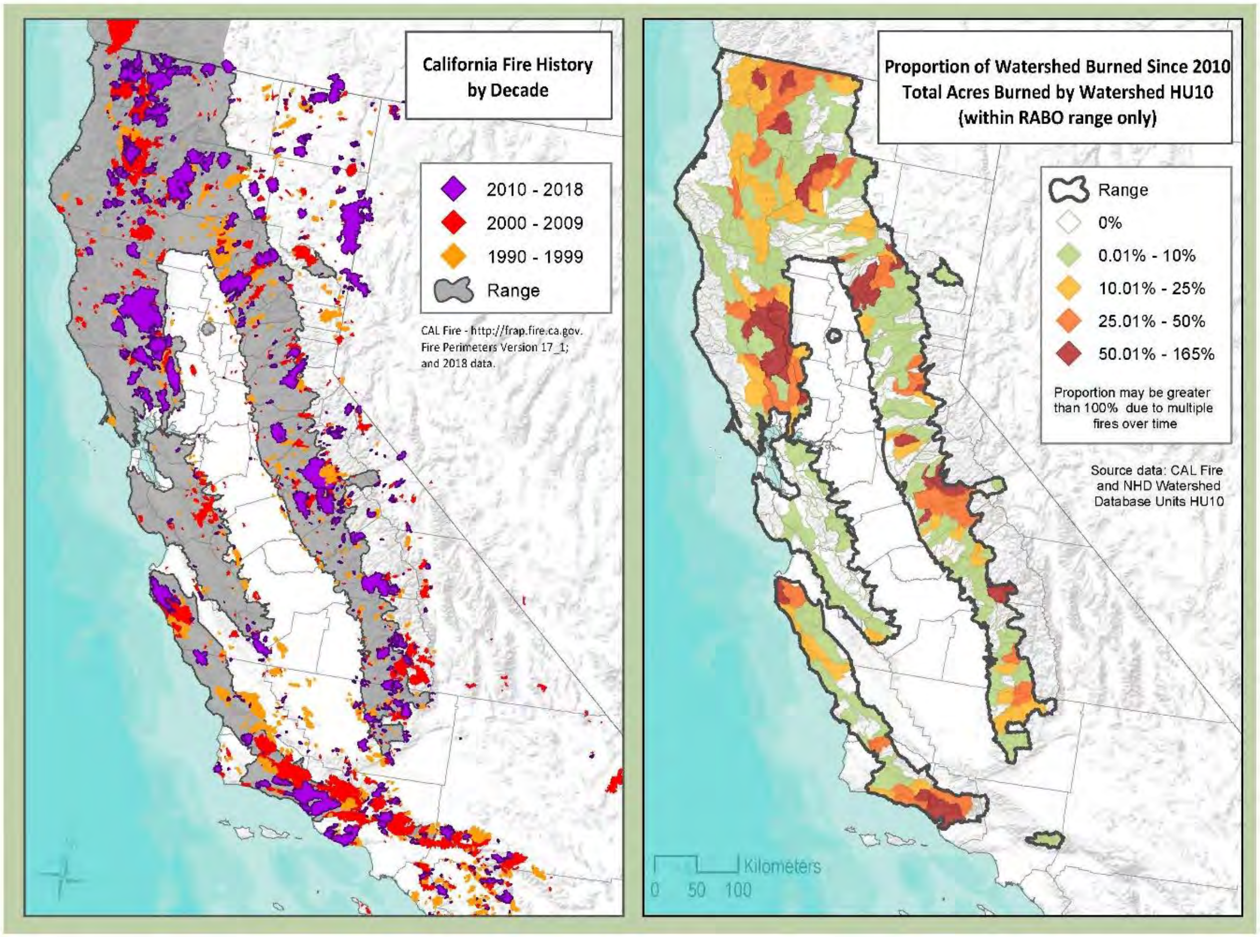


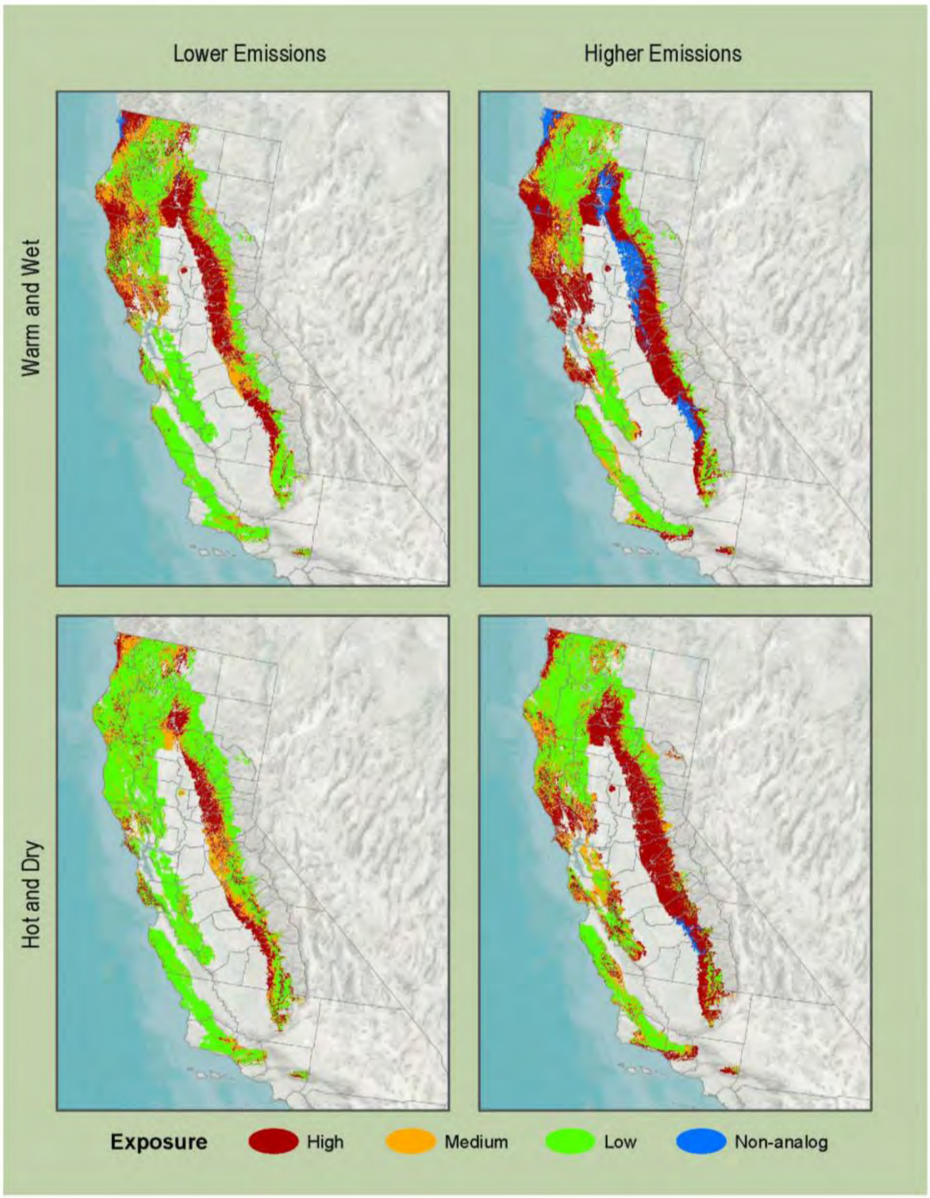
Figure 24. Fire history (1990-2018) and proportion of watershed burned (2010-2018) in California (CAL FIRE, NHD)

species with short generation times or in areas less affected by climate change, populations may be able to undergo evolutionary adaptation to the changing local environmental conditions (Hoffman and Sgrò 2011).

As previously described in the Seasonal Activity and Movements section, Foothill Yellow-legged Frog breeding is closely tied to water temperature, flow, and stage, and the species already adjusts its timing of oviposition by as much as a month in the same location during different water years, so the species may have enough inherent flexibility to reduce their vulnerability. The species appears fairly resilient to drought, fire, and flooding, at least in some circumstances. For example, after the 2012-2016 drought, the Loma Fire in late 2016, and severe winter flooding and landslides in 2016 and 2017, Foothill Yellow-legged Frog adults and metamorphs, as well as aquatic insects and rainbow trout, were abundant throughout Upper Llagas Creek in fall of 2017, and the substrate consisted of generally clean gravels and cobbles with only a slight silt coating in some pools (J. Smith pers. comm. 2017). The frogs and fish likely took refuge in a spring-fed pool, and the heavy rains scoured the fine sediments that eroded downstream (Ibid.). These refugia from the effects of climate change reduce the species' exposure, thereby reducing their vulnerability (Case et al. 2015).

Climate change models that evaluate the Foothill Yellow-legged Frog's susceptibility from a species and habitat perspective yield mixed results. An investigation into the possible effects of climate on California's native amphibians and reptiles used ecological niche models, future climate scenarios, and general circulation models to predict species-specific climatic suitability in 2050 (Wright et al. 2013). The results suggested approximately 90-100% of localities currently occupied by Foothill Yellow-legged Frogs are expected to remain climatically suitable in that time, and the proportion of currently suitable localities predicted to change ranges from -20% to 20% (Ibid.). However, a second study using a subset of these models found that 66.4% of currently occupied cells will experience reduced environmental suitability in 2050 (Warren et al. 2014). This analysis included 90 species of native California mammals, birds, reptiles, and amphibians. For context, over half of the taxa were predicted to experience > 80% reductions, a consistent pattern reflected across taxonomic groups (Ibid.).

A third analysis investigated the long-term risk of climate change by modeling the relative environmental stress a vegetative community would undergo in 2099 given different climate and greenhouse gas emission scenarios (Thorne et al. 2016). This model does not incorporate any Foothill Yellow-legged Frog-specific data; it strictly projects climatic stress levels vegetative communities will experience within the species' range boundaries (Ibid.). Unsurprisingly, higher emissions scenarios resulted in a greater proportion of habitat undergoing climatic stress (Figure 25). Perhaps counterintuitively, the warm and wet scenario resulted in a greater amount of stress than the hot and dry scenario. When high emissions and warm and wet changes are combined, a much greater proportion of the vegetation communities will experience "non-analog" conditions, those outside of the range of conditions currently known in California (Ibid.).



Source - model extracts from -Thorne, J.H. et al. (2016) A climate change vulnerability assessment of California's terrestrial vegetation. CDFW.

Figure 25. Vegetative community exposure to climate change in 2099 based on Thorne et al. (2016).

Habitat Restoration and Species Surveys

Potential conflicts between managing riverine habitat below dams for both cold-water adapted salmonids and Foothill Yellow-legged Frogs was discussed previously. In addition to problems with temperatures and pulse flows, some stream restoration projects aimed at physically creating or improving salmonid habitat can also adversely affect the species. For example, boulder deflectors were placed in Hurdygurdy Creek (Del Norte County) to create juvenile steelhead rearing habitat; deflectors change broad, shallow, low-velocity reaches into narrower, deeper, faster reaches preferred by the fish (Fuller and Lind 1992). Foothill Yellow-legged Frogs were documented using the restoration reach as breeding habitat annually prior to placement of the boulders, but no breeding was detected in the following three years, suggesting this project eliminated the conditions the frogs require (Ibid.). In addition, a fish ladder to facilitate salmonid migration above the Alameda Creek Diversion Dam was recently constructed on a Foothill Yellow-legged Frog lek site, and the frogs may become trapped in the ladder (M. Grefsrud pers. comm. 2019). Use of rotenone to eradicate non-native fish as part of a habitat restoration project is rare, but if it is applied in streams occupied by Foothill Yellow-legged Frogs, it can kill tadpoles but is unlikely to impact post-metamorphic frogs (Fontenot et al. 1994). Metamorphosing tadpoles may be able to stay close enough to the surface to breathe air and survive but may display lethargy and experience increased susceptibility to predation (Ibid.).

Commonly when riparian vegetation is removed, regulatory agencies require a greater amount to be planted as mitigation to offset the temporal loss of habitat. This practice can have adverse impacts on Foothill Yellow-legged Frogs by reducing habitat suitability. Foothill Yellow-legged Frogs have been observed moving into areas where trees were recently removed, and they are known to avoid heavily shaded areas (Welsh and Hodgson 2011, M. Grefsrud pers. comm. 2019).

Biologists conducting surveys in Foothill Yellow-legged Frog habitat can trample egg masses or larvae if they are not careful. One method for sampling fish is electroshocking, which runs a current through the water that stuns the fish temporarily allowing them to be captured. Post-metamorphic frogs are unlikely to be killed by electroshocking; however, at high frequencies (60 Hz), they may experience some difficulty with muscle coordination for a few days (Allen and Riley 2012). This could increase their risk of predation. At 30 Hz, there were no differences between frogs that were shocked and controls (Ibid.). Tadpoles are more similar to fish in tail muscle and spinal structure and are at higher risk of injuries; however, researchers who reported observing stunned tadpoles noted they appeared to recover completely within several seconds (Ibid.). Adverse effects to Foothill Yellow-legged Frogs from electrofishing may only happen at frequencies higher than those typically used for fish sampling (Ibid.)

Small Population Sizes

Small populations are at greater risk of extirpation, primarily through the disproportionately greater impact of demographic, environmental, and genetic stochasticity on them compared to large populations, so any of the threats previously discussed will likely have an even greater adverse impact on small populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). This risk of extinction from genetic stochasticity is amplified when connectivity between the small populations, and thus gene flow,

is impeded (Fahrig and Merriam 1985, Taylor et al. 1993, Lande and Shannon 1996, Palstra and Ruzzante 2008). Genetic diversity provides capacity to evolve in response to environmental changes, and the "rescue effect" of gene flow is important in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). However, the rescue effect is diminished in conditions of high local environmental stochasticity of recruitment or survival (Eriksson et al. 2014). In addition, populations living near their physiological limits and lacking adaptive capacity may not be able to evolve in response to rapid changes (Hoffmann and Sgrò 2011). Furthermore, while pathogens or parasites rarely result in host extinction, they can increase its likelihood in small populations by driving the host populations below a critically low threshold beneath which demographic stochasticity can lead to extinction, even if they possess the requisite genetic diversity to adapt to a changed environment (Gomulkiewicz and Holt 1995, Adams et al. 2017b).

A Foothill Yellow-legged Frog PVA revealed that, even with no dam effects considered (e.g., slower growth and increased egg and tadpole mortality), populations with the starting average density of adult females in regulated rivers (4.6/km [2.9/mi]) were four times more likely to go extinct within 30 years than those with the starting average density of adult females from unregulated rivers (32/km [120/mi]) (Kupferberg et al. 2009c). When the density of females in sparse populations was used (2.1/km [1.3/mi], the 30-year risk of extinction increased 13-fold (Ibid.). With dam effects, a number of the risk factors above contribute to the additional probability of local extinction such as living near their lower thermal tolerance and reduced recruitment and survival from scouring and stranding flows, poor food quality, and increased predation and competition (Kupferberg 1997a; Hoffmann and Sgrò 2011; Kupferberg et al. 2011a,b; Kupferberg et al. 2012; Eriksson et al. 2014). These factors act synergistically, contributing in part to the small size, high divergence, and low genetic diversity exhibited by many Foothill Yellow-legged Frog populations located in highly regulated watersheds (Kupferberg et al. 2012, Peek 2018).

EXISTING MANAGEMENT

Land Ownership within the California Range

Using the Department's Foothill Yellow-legged Frog range boundary and the California Protected Areas Database (CPAD), a GIS dataset of lands that are owned in fee title and protected for open space purposes by over 1,000 public agencies or non-profit organizations, the total area of the species' range in California comprises 13,620,447 ha (33,656,857 ac) (CPAD 2019, CWHR 2019). Approximately 37% is owned by federal agencies, 80% of which (4,071,178 ha [10,060,100 ac]) is managed by the Forest Service (Figure 26). Department of Fish and Wildlife-managed lands, State Parks, and other State agency-managed lands constitute around 2.6% of the range. The remainder of the range includes < 1% Tribal lands, 2.3% other conserved lands (e.g., local and regional parks), and 57% private and government-managed lands that are not protected for open space purposes. It is important to note that even if included in the CPAD, a property's management does not necessarily benefit Foothill Yellow-legged Frogs, but in some cases changes in management to conserve the species may be easier to undertake than on private lands or public lands not classified as conserved.

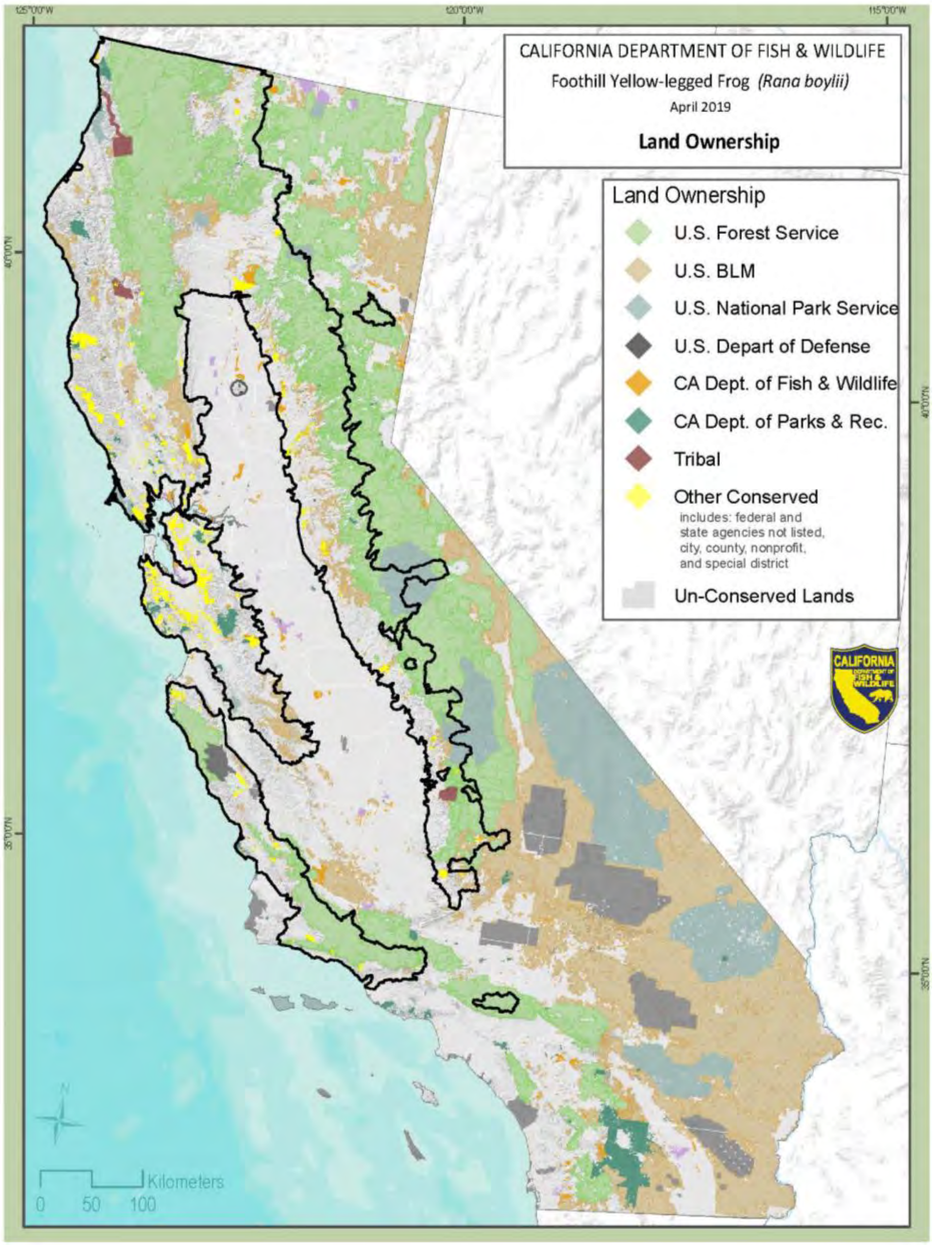


Figure 26. Conserved, Tribal, and other lands (BLM, CMD, CPAD, CWHR, DOD)

Statewide Laws

The laws and regulations governing land management within the Foothill Yellow-legged Frog's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California that may provide some level of protection for Foothill Yellow-legged Frogs and their habitat. The following is not an exhaustive list.

National Environmental Policy Act and California Environmental Quality Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. As a BLM and Forest Service Sensitive Species, impacts to Foothill Yellow-legged Legged Frogs are considered during NEPA analysis; however, the law has no requirement to minimize or mitigate adverse effects.

The California Environmental Quality Act (CEQA) is similar to NEPA; it requires state and local agencies to identify, analyze, and consider alternatives, and to publicly disclose environmental impacts from projects over which they have discretionary authority (Pub. Resources Code § 21000 et seq.). CEQA differs substantially from NEPA in requiring mitigation for significant adverse effects to a less than significant level unless overriding considerations are documented. CEQA requires an agency find projects may have a significant effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380.). CEQA establishes a duty for public agencies to avoid or minimize such significant effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to Foothill Yellow-legged Frogs, as an SSC, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA. However, a lead agency is not required to make a mandatory finding of significance conclusion unless it determines on a project-specific basis that the species meets the CEQA criteria for rare, threatened, or endangered.

Clean Water Act and Porter-Cologne Water Quality Control Act

The Clean Water Act originated in 1948 as the Federal Water Pollution Control Act of 1948. It was heavily amended in 1972 and became known as the Clean Water Act (CWA). The purpose of the CWA was to establish regulations for the discharge of pollutants into waters of the United States and establish quality standards for surface waters. Section 404 of the CWA forbids the discharge of dredged or fill material into waters and wetlands without a permit from the ACOE. The CWA also requires an alternatives analysis, and the ACOE is directed to issue their permit for the least environmentally damaging practicable alternative. The definition of waters of the United States has changed substantially over time based on Supreme Court decisions and agency rule changes.

The Porter-Cologne Water Quality Act was established by the State in 1969 and is similar to the CWA in that it establishes water quality standards and regulates discharge of pollutants into state waters, but it

also administers water rights which regulate water diversions and extractions. The SWRCB and nine Regional Water Boards share responsibility for implementation and enforcement of Porter-Cologne as well as the CWA's National Pollutant Discharge Elimination System permitting.

Federal and California Wild and Scenic Rivers Acts

In 1968, the U.S. Congress passed the federal Wild and Scenic Rivers Act (WSRA) (16 U.S.C. § 1271, et seq.) which created the National Wild and Scenic River System. The WSRA requires the federal government to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The WSRA prohibits the federal government from building, licensing, funding or otherwise aiding in the building of dams or other project works on rivers or segments of designated rivers. The WSRA does not give the federal government control of private property including development along protected rivers.

California's Wild and Scenic Rivers Act was enacted in 1972 so rivers that "possess extraordinary scenic, recreational, fishery, or wildlife values shall be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the state." (Pub. Res. Code, § 5093.50). Designated waterways are codified in Public Resources Code sections 5093.50-5093.70. In 1981, most of California's designated Wild and Scenic Rivers were adopted into the federal system. Currently in California, 3,218 km (1,999.6 mi) of 23 rivers are protected by the WSRA, most of which are located in the northwest. Foothill Yellow-legged Frogs have been observed in 11 of the 17 designated rivers within their range (CNDDB 2019).

Lake and Streambed Alteration Agreements

Fish and Game Code Section 1602 requires entities to notify the Department of activities that "divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake." If the activity may substantially adversely affect an existing fish and wildlife resource, the Department may enter into a lake or streambed alteration agreement with the entity that includes reasonable measures necessary to protect the fish or wildlife resource (Fish & G. Code, §1602, subd. (a)(4)(B)). A lake or stream alteration agreement does not authorize take of species listed as candidates, threatened, or endangered under CESA (see Protection Afforded by Listing for CESA compliance requirements).

Medicinal and Adult-Use Cannabis Regulation and Safety Act

The commercial cannabis cultivation industry is unique in that any entity applying for an annual cannabis cultivation license from California Department of Food and Agriculture (CDFA) must include "a copy of any final lake or streambed alteration agreement…or written verification from the California Department of Fish and Wildlife that a lake or streambed alteration agreement is not required" with their license application (Cal. Code Regs., tit. 3, § 8102, subd. (v)). The SWRCB also enforces the laws related to waste discharge and water diversions associated with cannabis cultivation (Cal. Code Regs., tit. 3, § 8102, subd. (p)).

Forest Practice Act

The Forest Practice Act was originally enacted in 1973 to ensure that logging in California is undertaken in a manner that will also preserve and protect the State's fish, wildlife, forests, and streams. This law and the regulations adopted by the California Board of Forestry and Fire Protection (BOF) pursuant to it are collectively referred to as the Forest Practice Rules. The Forest Practice Rules implement the provisions of the Forest Practice Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. The California Department of Forestry and Fire Protection (CAL FIRE) enforces these laws and regulations governing logging on private land.

Federal Power Act

The Federal Power Act and its major amendments are implemented and enforced by FERC and require licenses for dams operated to generate hydroelectric power. One of the major amendments required that these licenses "shall include conditions for the protection, mitigation and enhancement of fish and wildlife including related spawning grounds and habitat" (ECPA 1986). Hydropower licenses granted by FERC are usually valid for 30-50 years. If a licensee wants to renew their license, it must file a Notice of Intent and a pre-application document five years before the license expires to provide time for public scoping, any potentially new studies necessary to analyze project impacts and alternatives, and preparation of environmental documents. The applicant must officially apply for the new license at least two years before the current license expires.

As a federal agency, FERC must comply with federal environmental laws prior to issuing a new license or relicensing an existing hydropower project, which includes NEPA and ESA. As a result of environmental compliance or settlement agreements formed during the relicensing process, some operations have been modified and habitat restored to protect fish and wildlife. For example, the Lewiston Dam relicensing resulted in establishment of the Trinity River Restoration Program, which takes an ecosystem-approach to studying dam effects and protecting and restoring fish and wildlife populations downstream of the dam (Snover and Adams 2016). Similarly, relicensing of the Rock Creek-Cresta Project on the North Fork Feather River resulted in establishment of a multi-stakeholder Ecological Resources Committee (ERC). As a result of the ERC's studies and recommendations, pulse flows for whitewater boating were suspended for several years following declines of Foothill Yellow-legged Frogs, and the ERC is currently working toward augmenting the population in an attempt to increase abundance to a viable level.

Administrative and Regional Plans

Forest Plans

NORTHWEST FOREST PLAN

In 1994, BLM and the Forest Service adopted the Northwest Forest Plan to guide the management of over 97,000 km^2 (37,500 mi^2) of federal lands in portions of northwestern California, Oregon, and Washington. The Northwest Forest Plan created an extensive network of forest reserves including

Riparian Reserves. Riparian Reserves apply to all land designations to protect riparian dependent resources. With the exception of silvicultural activities consistent with Aquatic Conservation Strategy objectives, timber harvest is not permitted within Riparian Reserves, which can vary in width from 30 to 91 m (100-300 ft) on either side of streams, depending on the classification of the stream or waterbody (USFS and BLM 1994). Fuel treatment and fire suppression strategies and practices implemented within these areas are designed to minimize disturbance.

Sierra Nevada Forest Plan

Land and Resource Management Plans for forests in the Sierra Nevada were changed in 2001 by the Sierra Nevada Forest Plan Amendment and subsequently adjusted via a supplemental Environmental Impact Statement and Record of Decision in 2004, referred to as the Sierra Nevada Framework (USFS 2004). This established an Aquatic Management Strategy with Goals including maintenance and restoration of habitat to support viable populations of riparian-dependent species; spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction; instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats; the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity; and prevention of new introductions of invasive species and reduction of invasive species impacts that adversely affect the viability of native species. The Sierra Nevada Framework also includes Riparian Conservation Objectives and associated standards and guidelines specific to aquatic-dependent species, including the Foothill Yellow-legged Frog.

Resource Management Plans

Sequoia, Kings Canyon, and Yosemite National Parks fall within the historical range of the Foothill Yellow-legged Frog, but the species has been extirpated from these areas. The guiding principles for managing biological resources on National Park Service lands include maintenance of animal populations native to park ecosystems (Hayes et al. 2016). They also commit the agency to work with other land managers on regional scientific and planning efforts and maintenance or reintroduction of native species to the parks including conserving Foothill Yellow-legged Frogs in the Sierra Nevada (USDI NPS 1999 as cited in Hayes et al. 2016). A Sequoia and Kings Canyon National Parks Resource Management Plan does not include specific management goals for Foothill Yellow-legged Frogs, but it does include a discussion of the factors leading to the species' decline and measures to restore the integrity of aquatic ecosystems (Ibid.). The Yosemite National Park Resource Management Plan includes a goal of restoring Foothill Yellow-legged Frogs to the Upper Tuolumne River below Hetch Hetchy Reservoir (USDI NPS 2003 as cited in Hayes et al. 2016).

FERC Licenses

Dozens of hydropower dams have been relicensed in California since 1999, and several are in the process of relicensing (FERC 2019). In addition to following the Federal Power Act and other applicable federal laws, Porter-Cologne Water Quality Act requires non-federal dam operators to obtain a Water Quality Certification (WQC) from the SWRCB. Before it can issue the WQC, the SWRCB must consult with

the Department regarding the needs of fish and wildlife. Consequently, SWRCB includes conditions in the WQC that seek to minimize adverse effects to native species, and Foothill Yellow-legged Frogs have received some special considerations due to their sensitivity to dam operations during these licensing processes. As discussed above, the typical outcome is formation of an ERC-type group to implement the environmental compliance requirements and recommend changes to flow management to reduce impacts. Foothill Yellow-legged Frog-specific requirements fall into three general categories: data collection, modified flow regimes, and standard best management practices.

Data Collection

When little is known about the impacts of different flows and temperatures on Foothill Yellow-legged Frog occupancy and breeding success, data are collected and analyzed to inform recommendations for future modifications to operations such as temperature trigger thresholds. These surveys include locating egg masses and tadpoles, monitoring temperatures and flows, and recording their fate (e.g., successful development and metamorphosis, displacement, desiccation) during different flow operations and different water years. Examples of licenses with these conditions include the Lassen Lodge Project (FERC 2018), Rock Creek-Cresta Project (FERC 2009a), and El Dorado Project (EID 2007).

Modified Flow Regimes

When enough data exist to understand the effect of different operations on Foothill Yellow-legged Frog occupancy and success, license conditions may include required minimum seasonal instream flows, specific thermal regimes, gradual ramping rates to reduce the likelihood of early life stage scour or stranding, or freshet releases (winter/spring flooding simulation) to maintain riparian processes, and cancellation or prohibition of recreational pulse flows during the breeding season. Examples of licenses with these conditions include the Poe Hydroelectric Project (SWRCB 2017), Upper American Project (FERC 2014), and Pit 3, 4, 5 Project (FERC 2007b).

Best Management Practices

Efforts to reduce the impacts from maintenance activities and indirect operations include selective herbicide and pesticide application, aquatic invasive species monitoring and control, erosion control, and riparian buffers. Examples of licenses with these conditions include the South Feather Project (SWRCB 2018), Spring Gap-Stanislaus Project (FERC 2009b), and Chili Bar Project (FERC 2007a).

Habitat Conservation Plans and Natural Community Conservation Plans

Non-federal entities can obtain authorization for take of federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of a Habitat Conservation Plan (HCP) pursuant to Section 10 of the ESA. The take authorization can extend to species not currently listed under ESA but which may become listed as threatened or endangered over the term of the HCP, which is often 25-75 years. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. A Natural Community Conservation Plan (NCCP) identifies and provides for the protection of plants, animals, and their

habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs that include Foothill Yellow-legged Frogs as a covered species, two of which are also NCCPs.

Humboldt Redwood (formerly Pacific Lumber) Company

The Humboldt Redwood Company (HRC) HCP covers 85,672 ha (211,700 ac) of private Coast Redwood and Douglas-fir forest in Humboldt County (HRC 2015). It is a 50-year HCP/incidental take permit (ITP) that was executed in 1999, revised in 2015 as part of its adaptive management strategy, and expires on March 1, 2049. The HCP includes an Amphibian and Reptile Conservation Plan and an Aquatics Conservation Plan with measures designed to sustain viable populations of Foothill Yellow-legged Frogs and other covered aquatic herpetofauna. These conservation measures include prohibiting or limiting tree harvest within Riparian Management Zones (RMZ), controlling sediment by maintaining roads and hillsides, restricting controlled burns to spring and fall in areas outside of the RMZ, conducting effectiveness monitoring throughout the life of the HCP, and use the data collected to adapt monitoring and management plans accordingly.

Watershed assessment surveys include observations of Foothill Yellow-legged Frogs and have documented their widespread distribution on HRC lands with a pattern of fewer near the coast in the fog belt and more inland (S. Chinnici pers. comm. 2017). The watersheds within the property are largely unaffected by dam-altered flow regimes or non-native species, so aside from the operations described under Timber Harvest above that are minimized to the extent feasible, the focus on suitable temperatures and denser canopy cover for salmonids may reduce habitat suitability for Foothill Yellow-legged Frogs over time (Ibid.).

San Joaquin County Multi-Species Habitat Conservation and Open Space Plan

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) is a 50-year HCP/ITP that was signed by the USFWS on November 14, 2000 (San Joaquin County 2000). The SJMSCP covers almost all of San Joaquin County except federal lands, a few select projects, and some properties with certain land uses, roughly 364,000 ha (900,000 ac). At the time of execution, approximately 70 ha (172 ac) of habitat within the SJMSCP area in the southwest portion of the county were considered occupied by Foothill Yellow-legged Frogs with another 1,815 ha (4,484 ac) classified as potential habitat, but it appears the species had been considered extirpated before then (Jennings and Hayes 1994, San Joaquin County 2000, Lind 2005). The HCP estimates around 8% of the combined modeled habitat would be converted to other uses over the permit term, but the establishment of riparian preserves with buffers around Corral Hollow Creek, where the species occurred historically, was expected to offset those impacts (San Joaquin County 2000, SJCOG 2018). However, the HCP did not require surveys to determine if Foothill Yellow-legged Frogs are benefiting (M. Grefsrud pers. comm. 2019).

East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan

The East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan (ECCC HCP/NCCP) is a multi-jurisdictional 30-year plan adopted in 2007 that covers over 70,423 ha (174,018 ac) in eastern Contra Costa County (Jones & Stokes 2006). The Foothill Yellow-legged Frog appears to be

extirpated from the ECCC HCP/NCCP area (CNDDB 2019). Nevertheless, suitable habitat was mapped, and impacts were estimated at well under 1% of both breeding and migratory habitat (Jones & Stokes 2006). One of the HCP/NCCP's objectives is acquiring high-quality Foothill Yellow-legged Frog habitat that has been identified along Marsh Creek (Ibid.). In 2017, the Viera North Peak 65 ha (160 ac) property was acquired that possesses suitable habitat for Foothill Yellow-legged Frogs (ECCCHC 2018).

Santa Clara Valley Habitat Plan

The Santa Clara Valley Habitat Plan (SCVHP) is a 50-year HCP/NCCP covering over 210,237 ha (519,506 ac) in Santa Clara County (ICF 2012). As previously mentioned, Foothill Yellow-legged Frogs appear to have been extirpated from lower elevation sites, particularly below reservoirs in this area. Approximately 17% of modeled Foothill Yellow-legged Frog habitat, measured linearly along streams, was already permanently preserved, and the SCVHP seeks to increase that to 32%. The maximum allowable habitat loss is 11 km (7 mi) permanent loss and 3 km (2 mi) temporary loss, while 167 km (104 mi) of modeled habitat is slated for protection. By mid-2018, 8% of impact area had been accrued and 3% of habitat protected (SCVHA 2019).

Green Diamond Aquatic Habitat Conservation Plan

Green Diamond Resources Company has an Aquatic Habitat Conservation Plan (AHCP) covering 161,875 ha (400,000 ac) of their land that is focused on cold-water adapted species, but many of the conservation measures are expected to benefit Foothill Yellow-legged Frogs as well (K. Hamm pers. comm. 2017). Examples include slope stability and road management measures to reduce stream sedimentation from erosion and landslides, and limiting water drafting during low flow periods with screens over the pumps to avoid entraining animals (Ibid.). Although creating more open canopy areas and warmer water temperatures is not the goal of the AHCP, the areas that are suitable for Foothill Yellow-legged Frog breeding are likely to remain that way because they are wide channels that receive sufficient sunlight (Ibid.).

SUMMARY OF LISTING FACTORS

CESA's implementing regulations identify key factors relevant to the Department's analyses and the Fish and Game Commission's decision on whether to list a species as threatened or endangered. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

Present or Threatened Modification or Destruction of Habitat

Most of the factors affecting ability to survive and reproduce listed above involve destruction or degradation of Foothill Yellow-legged Frog habitat. The most widespread, and potentially most significant, threats are associated with dams and their flow regimes, particularly in areas where they are concentrated and occur in a series along a river. Dams and the way they are operated can have up- and downstream impacts to Foothill Yellow-legged Frogs. They can result in confusing natural breeding cues, scouring and stranding of egg masses and tadpoles, reducing quality and quantity of breeding and rearing habitat, reducing tadpole growth rate, impeding gene flow among populations, and establishing and spreading non-native species (Hayes et al. 2016). These impacts appear to be most severe when the dam is operated for the generation of hydropower utilizing hydropeaking and pulse flows (Kupferberg et al. 2009c, Peek 2018). Foothill Yellow-legged Frog abundance below dams is an average of five times lower than in unregulated rivers (Kupferberg et al. 2012). The number, height, and distance upstream of dams in a watershed influenced whether Foothill Yellow-legged Frogs still occurred at sites where they had been present in 1975 in California (Ibid.). Water diversions for agricultural, industrial, and municipal uses also reduce the availability and quality of Foothill Yellow-legged Frog habitat. Dams are concentrated in the Bay Area, Sierra Nevada, and southern California (Figure 17), while hydropower plants are densest in the northern and central Sierra Nevada (Figure 18).

With predicted increases in the human population, ambitious renewable energy targets, higher temperatures, and more extreme and variable precipitation falling increasingly more as rain rather than snow, the need for more and taller dams and water diversions for hydroelectric power generation, flood control, and water storage and delivery is not expected to abate in the future. California voters approved Proposition 1, the Water Quality, Supply and Infrastructure Improvement Act of 2014, which dedicated $2.7 billion to water storage projects (PPIC 2018). In 2018, the California Water Commission approved funding for four new dams in California: expansion of Pacheco Reservoir (Santa Clara County), expansion of Los Vaqueros Reservoir (Contra Costa County), Temperance Flat Dam (new construction) on the San Joaquin River (Fresno County), and the off-stream Sites Reservoir (new construction) diverting the Sacramento River (Colusa County) (CWC 2019). No historical records of Foothill Yellow-legged Frogs from the Los Vaqueros or Sites Reservoir areas exist in the CNDDB, and one historical (1950) collection is documented from the Pacheco Reservoir area (CNDDB 2019). However, the proposed Temperance Flat Dam site is downstream of one of the only known extant populations of Foothill Yellow-legged Frogs in the East/Southern Sierra clade (Ibid.).

The other widespread threat to Foothill Yellow-legged Frog habitat is climate change, although the severity of its impacts is somewhat uncertain. While drought, wildland fires, floods, and landslides are natural and ostensibly necessary disturbance events for preservation of native biodiversity, climate change is expected to result in increased frequency and severity of these events in ways that may exceed species' abilities to adapt (Williams et al. 2008, Hoffmann and Sgrò 2011, Keely and Syphard 2016). These changes can lead to increased competition, predation, and disease transmission as species become concentrated in areas that remain wet into the late summer (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Loss of riparian vegetation from wildland fires can result in increased stream temperatures or concentrations of nutrients and trace heavy metals that inhibit growth and survival

(Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Stream sedimentation from landslides following fire or excessive precipitation can destroy or degrade breeding and rearing habitat (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). At least some models predict unprecedented dryness in the latter half of the century (Cook et al. 2015). The effects of climate change will be realized across the Foothill Yellow-legged Frog's range, and their severity will likely differ in ways that are difficult to predict. However, the impacts from extended droughts will likely be greatest in the areas that are naturally more arid, the lower elevations and latitudes of southern California and the foothills surrounding the Central Valley (Figure 21).

While most future urbanization is predicted to occur in areas outside of the Foothill Yellow-legged Frog's range, it has already contributed to the loss and fragmentation of Foothill Yellow-legged Frog habitat in California. In addition, the increased predation, wildland fires, introduced species, road mortality, disease transmission, air and water pollution, and disturbance from recreation that can accompany urbanization expand its impact far beyond its physical footprint (Davidson et al. 2002, Syphard et al. 2007, Cook et al. 2012, Bar-Massada et al. 2014). Within the Foothill Yellow-legged Frog's historical range, these effects appear most significant and extensive in terms of population extirpations in southern California and the San Francisco Bay Area.

Several other activities have the potential to destroy or degrade Foothill Yellow-legged Frog habitat, but they are less common across the range. They also tend to have relatively small areas of impact, although they can be significant in those areas, particularly if populations are already small and declining. These include impacts from mining, cannabis cultivation, vineyard expansion, overgrazing, timber harvest, recreation, and some stream habitat restoration projects (Harvey and Lisle 1998, Belsky et al. 1999, Merelender 2000, Pilliod et al. 2003, Bauer et al. 2015, Kupferberg and Furey 2015).

Overexploitation

Foothill Yellow-legged Frogs are not threatened by overexploitation. There is no known pet trade for Foothill Yellow-legged Frogs (Lind 2005). During the massive frog harvest that accompanied the Gold Rush, some Foothill Yellow-legged Frogs were collected, but because they are relatively small and have irritating skin secretions, there was much less of a market for them (Jennings and Hayes 1985). Within these secretions is a peptide with antimicrobial activity that is particularly potent against *Candida albicans*, a human pathogen that has been developing resistance to traditional antifungal agents (Conlon et al. 2003). However, the peptide's therapeutic potential is limited by its strong hemolytic activity, so further studies will focus on synthesizing analogs that can be used as antifungals, and collection of Foothill Yellow-legged Frogs for lab cultures is unlikely (Ibid.).

Like all native California amphibians, collection of Foothill Yellow-legged Frogs is unlawful without a permit from the Department. They may only be collected for scientific, educational, or propagation reasons through a Scientific Collecting Permit (Fish & G. Code § 1002 et seq.). The Department has the discretion to limit or condition the number of individuals collected or handled to ensure no significant adverse effects. Incidental harm from authorized activities on other aquatic species can be avoided or minimized by the inclusion of special terms and conditions in permits.

Predation

Predation is a likely contributor to Foothill Yellow-legged Frog population declines where the habitat is degraded by one or many other risk factors (Hayes and Jennings 1986). Predation by native gartersnakes can be locally substantial; however, it may only have an appreciable population-level impact if the availability of escape refugia is diminished. For example, when streams dry and only pools remain, Foothill Yellow-legged Frogs are more vulnerable to predation by native and non-native species because they are concentrated in a small area with little cover.

Several studies have demonstrated the synergistic impacts of predators and other stressors. Foothill Yellow-legged Frogs, primarily as demonstrated through studies on tadpoles, are more susceptible to predation when exposed to some agrochemicals, cold water, high velocities, excess sedimentation, and even the presence of other species of predators (Harvey and Lisle 1998, Adams et al. 2003, Olson and Davis 2009, Kupferberg et al. 2011b, Kerby and Sih 2015, Catenazzi and Kupferberg 2018). Foothill Yellow-legged Frog tadpoles appear to be naïve to chemical cues from some non-native predators; they have not evolved those species-specific predator avoidance behaviors (Paoletti et al. 2011). Furthermore, early life stages are often more sensitive to environmental stressors, making them more vulnerable to predation, and Foothill Yellow-legged Frog population dynamics are highly sensitive to egg and tadpole mortality (Kats and Ferrer, 2003, Kupferberg et al. 2009c). Predation pressure is likely positively associated with proximity to anthropogenic changes in the environment, so in more remote or pristine places, it probably does not have a serious population-level impact.

Competition

Intra- and interspecific competition in Foothill Yellow-legged Frogs has been documented. Intraspecific male-to-male competition for females has been reported (Rombough and Hayes 2007). Observations include physical aggression and a non-random mating pattern in which larger males were more often engaged in breeding (Rombough and Hayes 2007, Wheeler and Welsh 2008). A behavior resembling clutch-piracy, where a satellite male attempts to fertilize already laid eggs, has also been documented (Rombough and Hayes 2007). These acts of competition play a role in population genetics, but they likely do not result in serious physical injury or mortality. Intraspecific competition among Foothill Yellow-legged Frog tadpoles was negligible (Kupferberg 1997a).

Interspecific competition appears to have a greater possibility of resulting in adverse impacts. Kupferberg (1997a) did not observe a significant change in tadpole mortality for Foothill Yellow-legged Frogs raised with Pacific Treefrogs compared to single-species controls. However, when reared together, Foothill Yellow-legged Frog tadpoles lost mass, while Pacific Treefrog tadpoles increased mass (Kerby and Sih 2015). As described previously under Introduced Species, Foothill Yellow-legged Frog tadpoles experienced significantly higher mortality and smaller size at metamorphosis when raised with bullfrog tadpoles (Kupferberg 1997a). The mechanism of these declines appeared to be exploitative competition, as opposed to interference, through the reduction of available algal resources from bullfrog tadpole grazing in the shared enclosures (Ibid.).

The degree to which competition threatens Foothill Yellow-legged Frogs likely depends on the number and density of non-native species in the area rather than intraspecific competition, and co-occurrence of Foothill Yellow-legged Frog and bullfrog tadpoles may be somewhat rare since the latter tends to breed in lentic (still water) environments (M. van Hattem pers. comm. 2019). Interspecific competition with other native species may have some minor adverse consequences on fitness.

Disease

Currently, the only disease known to pose a serious risk to Foothill Yellow-legged Frogs is Bd. Until 2017, the only published studies on the impact of Bd on Foothill Yellow-legged Frog suggested it could reduce growth and body condition but was not lethal (Davidson et al. 2007, Lowe 2009, Adams et al. 2017b). However, two recent mass mortality events caused by chytridiomycosis proved they are susceptible to lethal effects, at least under certain conditions like drought-related concentration and presence of bullfrogs (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Some evidence indicates disease may have played a principal role in the disappearance of the species from southern California (Adams et al. 2017b). Bd is likely present in the environmental throughout the Foothill Yellow-legged Frog's range, and with bullfrogs and treefrogs acting as carriers, it will remain a threat to the species; however, given the dynamics of the two recent die-offs in the San Francisco Bay area, the probability of future outbreaks may be greater in areas where the species is under additional stressors like drought and introduced species (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Therefore, as with predation, Foothill Yellow-legged Frogs are less likely to experience the adverse impacts of diseases in more remote areas with fewer anthropogenic changes to the environment.

Other Natural Events or Human-Related Activities

Agrochemicals, particularly organophosphates that act as endocrine disruptors, can travel substantial distances from the area of application through atmospheric drift and have been implicated in the disappearance and declines of many species of amphibians in California including Foothill Yellow-legged Frogs (LeNoir et al. 1999, Davidson 2004, Lind 2005, Olson and Davis 2009). Foothill Yellow-legged Frogs appear to be significantly more sensitive to the adverse impacts of some pesticides than other native species (Sparling and Fellers 2009, Kerby and Sih 2015). These include smaller body size, slower development rate, increased time to metamorphosis, immunosuppression, and greater vulnerability to predation and malformations (Kiesecker 2002, Hayes et al. 2006, Sparling and Fellers 2009, Kerby and Sih 2015). Some of the most dramatic declines experienced by ranids in California occurred in the Sierra Nevada east of the San Joaquin Valley where over half of the state's total pesticide usage occurs (Sparling et al. 2001).

Many Foothill Yellow-legged Frog populations are small, isolated from other populations, and possess low genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). Genetic diversity is important in providing a population the capacity to evolve in response to environmental changes, and connectivity among populations is important for gene exchange and in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). Small populations are at much greater risk of extirpation primarily through the disproportionate impact of demographic, environmental, and genetic stochasticity than robust populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). Based on a Foothill Yellow-legged Frog PVA, populations in regulated rivers face a 4- to 13-fold greater extinction risk in 30 years than populations in unregulated rivers due to smaller population sizes (Kupferberg et al. 2009c). The threat posed by small population sizes is significant and the general pattern shows increases in severity from north to south; however, many sites, primarily in the northern Sierra Nevada, in watersheds with large hydropower projects are also at high risk.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). The conservation, protection, and enhancement of listed species and their habitat is of statewide concern (Fish & G. Code, § 2051(c)). CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86). The Fish and Game Code provides the Department with related authority to authorize "take" of species listed as threatened or endangered under certain circumstances (see, e.g., Fish & G. Code, §§ 2081, 2081.1, 2086, & 2835).

If the Foothill Yellow-legged Frog is listed under CESA, impacts of take caused by activities authorized through incidental take permits must be minimized and fully mitigated according to state standards (Fish & G. Code, § 2081, subd. (b)). These standards typically include protection of land in perpetuity with an easement, development and implementation of a species-specific adaptive management plan, and funding through an endowment to pay for long-term monitoring and maintenance to ensure the mitigation land meets performance criteria. Obtaining an incidental take permit is voluntary. The Department cannot force compliance; however, any person violating the take prohibition may be criminally and civilly liable under state law.

Additional protection of Foothill Yellow-legged Frogs following listing would be expected to occur through state and local agency environmental review under CEQA. CEQA requires affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on rare, threatened, and endangered species. In common practice, potential impacts to listed species are examined more closely in CEQA documents than potential impacts to unlisted species. Where significant impacts are identified under CEQA, the Department expects project-specific avoidance, minimization, and mitigation measures to benefit the species. State listing, in this respect, and consultation with the Department during state and local agency environmental review under CEQA, would be expected to benefit the Foothill Yellow-legged Frog in terms of reducing impacts from individual projects, which might otherwise occur absent listing.

For some species, CESA listing may prompt increased interagency coordination and the likelihood that state and federal land and resource management agencies will allocate funds toward protection and recovery actions. In the case of the Foothill Yellow-legged Frog, some multi-agency efforts exist, often associated with FERC license requirements, to improve habitat conditions and augment declining populations. The USFWS is leading an effort to develop regional Foothill Yellow-legged Frog conservation strategies, and CESA listing may result in increased priority for limited conservation funds.

LISTING RECOMMENDATION

CESA directs the Department to prepare this report regarding the status of the Foothill Yellow-legged Frog in California based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067).

The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science. In consideration of the scientific information contained herein, the Department has determined that listing the Foothill Yellow-legged Frog under CESA by genetic clade is the prudent approach due to the disparate degrees of imperilment among them. In areas of uncertainty, the Department recommends the higher protection status until clade boundaries can be better defined.

NORTHWEST/NORTH COAST: Not warranted at this time.

Clade-level Summary: This is the largest clade with the most robust populations (highest densities) and the greatest genetic diversity. This area is the least densely populated by humans; contains relatively few hydroelectric dams, particularly further north; and has the highest precipitation in the species' California range. The species is still known to occur in most, if not all, historically occupied watersheds; presumed extirpations are mainly concentrated in the southern portion of the clade around the heavily urbanized San Francisco Bay area. The proliferation of cannabis cultivation, particularly illicit grows in and around the Emerald Triangle, the apparent increase in severe wildland fires in the area, and potential climate change effects are cause for concern, so the species should remain a Priority 1 SSC here with continued monitoring for any change in its status.

WEST/CENTRAL COAST: Endangered.

Clade-level Summary: Foothill Yellow-legged Frogs appear to be extirpated from a relatively large proportion of historically occupied sites within this clade, particularly in the heavily urbanized northern portion around the San Francisco Bay. In the northern portion of the clade, nearly all the remaining populations (which may be fewer than a dozen) are located above dams, which line the mountains surrounding the Bay Area, and two are known to have undergone recent disease-associated die-offs. These higher elevation sites are more often intermittent or ephemeral streams than the lower in the watersheds. As a result, the more frequent and extreme droughts that have dried up large areas seem to have contributed to recent declines. Illegal cannabis cultivation, historical mining effects, overgrazing, and recreation likely contributed to declines and may continue to threaten remaining populations.

SOUTHWEST/SOUTH COAST: Endangered.

Clade-level Summary: The most extensive extirpations have occurred in this clade, and only two known extant populations remain. Both are small with apparently low genetic diversity, making them especially vulnerable to extirpation. This is also an area with a large human population, many dams, and naturally arid, fire-prone environments, particularly in the southern portion of the clade. Introduced species are widespread, and cannabis cultivation is rivaling the Emerald Triangle in some areas (e.g., Santa Barbara County). Introduced species, expanded recreation, disease, and flooding appear to have contributed to the widespread extirpations in southern California over 40 years ago.

FEATHER RIVER: Threatened.

Clade-level Summary: This is the smallest clade and has a high density of hydroelectric dams. It also recently experienced one of the largest, most catastrophic wildfires in California history. Despite these threats, Foothill Yellow-legged Frogs appear to continue to be relatively broadly distributed within the clade, although with all the dams in the area, most populations are likely disconnected. The area is more mesic and experienced less of a change in precipitation in the most recent drought than the clades south of it. The clade is remarkable genetically and morphologically as it is the only area where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs overlap and can hybridize. The genetic variation within the clade is greater than the other clades except for the Northwest/North Coast. Most of the area within the clade's boundaries is Forest Service-managed, and little urbanization pressure or known extirpations exist in this area. Recent FERC licenses in this area require Foothill Yellow-legged Frog specific conservation, which to date has included cancelling pulse flows, removing encroaching vegetation, and translocating egg masses and in situ head-starting to augment a population that had recently declined.

NORTHEAST/NORTHERN SIERRA: Threatened.

Clade-level Summary: The Northeast/Northern Sierra clade shares many of the same threats as the Feather River clade (e.g., relatively small area with many hydroelectric dams). The area is also more mesic and experienced less of a change in precipitation during the recent drought than more southern clades. However, this pattern may not continue as some models suggest loss of snowmelt will be greater in the northern Sierra Nevada, and one of the climate change exposure models suggests a comparatively large proportion of the lower elevations will experience climatic conditions not currently known from the area (i.e., non-analog) by the end of the century. Recent surveys suggest the area continues to support several populations of the species, some of which seem to remain robust, with a fairly widespread distribution. However, genetic analyses from several watersheds suggest many of these populations are isolated and diverging, particularly in regulated reaches with hydropeaking flows.

EAST/SOUTHERN SIERRA: Endangered.

Clade-level Summary: Like the Southwest/South Coast clade, widespread extirpations in this area were observed as early as the 1970s. Dams and introduced species were credited as causal factors in these declines in distribution and abundance, and mining and disease may also have contributed. This area is relatively arid, and drought effects appear greater here than in northern areas that exhibit both more precipitation and a smaller difference between drought years and the historical average. There is a relatively high number of hydroelectric power generating dams in series along the major rivers in this clade and at least one new proposed dam near one of the remaining populations. This area is also the most heavily impacted by agrochemicals from the San Joaquin Valley.

MANAGEMENT RECOMMENDATIONS

The Department has evaluated existing management recommendations and available literature applicable to the management and conservation of the Foothill Yellow-legged Frog to arrive at the following recommendations. These recommendations, which represent the best available scientific information, are largely derived the from the Foothill Yellow-legged Frog Conservation Assessment, the California Energy Commission's Public Interest Energy Research Reports, the Recovery Plans of West Coast Salmon and Steelhead, and the California Amphibian and Reptile Species of Special Concern (Kupferberg et al. 2009b,c; 2011a; NMFS 2012, 2013, 2014, 2016; Hayes et al. 2016, Thomson et al. 2016).

Conservation Strategies

Maintain current distribution and genetic diversity by protecting existing Foothill Yellow-legged Frog populations and their habitats and providing opportunities for genetic exchange. Increase abundance to viable levels in populations at risk of extirpation due to small sizes, when appropriate, through in situ or ex situ captive rearing and/or translocations. Use habitat suitability and hydrodynamic habitat models to identify historically occupied sites that may currently support Foothill Yellow-legged Frogs, or they could with minor habitat improvements or modified management. Re-establish extirpated populations in suitable habitat through captive propagation, rearing, and/or translocations. Prioritize areas in the southern portions of the species' range where extirpations and loss of diversity have been the most severe.

If establishing reserves, prioritize areas containing high genetic variation in Foothill Yellow-legged Frogs (and among various native species) and climatic gradients where selection varies over small geographical area because environmental heterogeneity can provide a means of maintaining phenotypic variability which increases the adaptive capacity of populations as conditions change. These reserves should provide connectivity to other occupied areas to facilitate gene flow and allow for ongoing selection to fire, drought, thermal stresses, and changing species interactions.

Research and Monitoring

Attempt to rediscover potentially remnant populations in areas where they are considered extirpated, prioritizing the southern portions of the species' range. Collect environmental DNA in addition to conducting visual encounter surveys to improve detectability. Concurrently assess presence of threats and habitat suitability to determine if future reintroductions may be possible. Collect genetic samples from any Foothill Yellow-legged Frogs captured for use in landscape genomics analyses and possible future translocation or captive propagation efforts. Attempt to better clarify clade boundaries where there is uncertainty. Study whether small populations are at risk of inbreeding depression, whether genetic rescue should be attempted, and if so, whether that results in hybrid vigor or outbreeding depression.

Continue to evaluate how water operations affect Foothill Yellow-legged Frog population demographics. Establish more long-term monitoring programs in regulated and unregulated (reference) rivers across the species' range but particularly in areas like the Sierra Nevada where most large hydropower dams in the species' range are concentrated. Assess whether the timing of pulse flows influences population dynamics, particularly whether early releases have a disproportionately large adverse effect by eliminating the reproductive success of the largest, most fecund females, who appear to breed earlier in the season. Investigate survival rates in poorly-understood life stages, such as tadpoles, young of the year, and juveniles. Determine the extent to which pulse flows contribute to displacement and mortality of post-metamorphic life stages.

Collect habitat variables that correlate with healthy populations to develop more site-specific habitat suitability and hydrodynamic models. Study the potential synergistic effect of increased flow velocity and decreased temperature on tadpole fitness. Examine the relationship between changes in flow, breeding and rearing habitat connectivity, and scouring and stranding to develop site-specific benign ramping rates. Incorporate these data and demographic data into future PVAs for use in establishing frog-friendly flow regimes in future FERC relicensing or license amendment efforts and habitat restoration projects. Ensure long-term funding for post-license or restoration monitoring to evaluate attainment of expected results and for use in adapting management strategies accordingly.

Evaluate the distribution of other threats such as cannabis cultivation, vineyard expansion, livestock grazing, mining, timber harvest, and urbanization and roads in the Foothill Yellow-legged Frog's range. Study the short- and long-term effects of wildland fires and fire management strategies. Assess the extent to which these potential threats pose a risk to Foothill Yellow-legged Frog persistence in both regulated and unregulated systems.

Investigate how reach-level or short-distance habitat suitability and hydrodynamic models can be extrapolated to a watershed level. Study habitat connectivity needs such as the proximity of breeding sites and other suitable habitats along a waterway necessary to maintain gene flow and functioning meta-population dynamics.

Habitat Restoration and Watershed Management

Remove or update physical barriers like dams and poorly constructed culverts and bridges to improve connectivity and natural stream processes. Remove anthropogenic features that support introduced predators and competitors such as abandoned mine tailing ponds that support bullfrog breeding. Conduct active eradication and management efforts to decrease the abundance of bullfrogs, non-native fish, and crayfish (where they are non-native). In managed rivers, manipulate stream flows to negatively affect non-native species not adapted to a winter flood/summer drought flow regime.

Adopt a multi-species approach to channel restoration projects and managed flow regimes (thermal, velocity, timing) and mimic the natural hydrograph to the greatest extent possible. When this is impractical or infeasible, focus on minimizing adverse impacts by gradually ramping discharge up and down, creating and maintaining gently sloping and sun-lit gravel bars and warm calm edgewater habitats for tadpole rearing, and mixing hypolimnetic water (from the lower colder stratum in a reservoir) with warmer surface water before release if necessary to ensure appropriate thermal conditions for successful metamorphosis. Promote restoration and maintenance of habitat heterogeneity (different depths, velocities, substrates, etc.) and connectivity to support all life stages and gene flow. Avoid damaging Foothill Yellow-legged Frog breeding habitat when restoring habitat for other focal species like anadromous salmonids.

Regulatory Considerations and Best Management Practices

Develop range-wide minimum summer baseflow requirements that protect Foothill Yellow-legged Frogs and their habitat with appropriate provisions to address regional differences using new more ecologically-meaningful approaches such as modified percent-of-flow strategies for watersheds (e.g., Mierau et al. 2018). Limit water diversions during the dry season and construction of new dams by focusing on off-stream water storage strategies.

Ensure and improve protection of riparian systems. Require maintenance of appropriate riparian buffers and canopy coverage (i.e., partly shaded) around occupied habitat or habitat that has been identified for potential future reintroductions. Restrict instream work to dry periods where possible. Prohibit fording in and around breeding habitat. Avoid working near streams after the first major rains in the fall when Foothill Yellow-legged Frogs may be moving upslope toward tributaries and overwintering sites. Use a 3 mm (0.125 in) mesh screen on water diversion pumps and limit the rate and amount of water diverted such that depth and flow remain sufficient to support Foothill Yellow-legged Frogs of all life stages occupying the immediate area and downstream. Install exclusion fencing where appropriate, and if Foothill Yellow-legged Frog relocation is required, conduct it early in the season because moving egg masses is easier than moving tadpoles.

Reduce habitat degradation from sedimentation, pesticides, herbicides, and other non-point source waste discharges from adjacent land uses including along tributaries of rivers and streams. Limit mining to parts of rivers not used for oviposition, such as deeper pools or reaches with few tributaries, and at times of year when frogs are more common in tributaries (i.e., fall and winter). Manage recreational activities in or adjacent to Foothill Yellow-legged Frog habitat (e.g., OHV and hiking trails, camp sites, boating ingress/egress, flows, and speeds) in a way that minimizes adverse impacts. Siting cannabis grows in areas with better access to roads, gentler slopes, and ample water resources could significantly reduce threats to the environment. Determine which, when, and where agrochemicals should be restricted to reduce harm to Foothill Yellow-legged Frogs and other species. Ensure all new road crossings and upgrades to existing crossings (bridges, culverts, fills, and other crossings) accommodate at least 100-year flood flows and associated bedload and debris.

Partnerships and Coordination

Establish collaborative partnerships with agencies, universities, and non-governmental organizations working on salmon and steelhead recovery and stream restoration. Anadromous salmonids share many of the same threats as Foothill Yellow-legged Frogs, and recovery actions such as barrier removal, restoration of natural sediment transport processes, reduction in pollution, and eradication of non-native predators would benefit frogs as well. Ensure Integrated Regional Water Management Plans and fisheries restoration programs take Foothill Yellow-legged Frog conservation into consideration during design, implementation, and maintenance.

Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems. Promote and implement initiatives and programs that improve water conservation use efficiency, reduce greenhouse gas emissions, promote sustainable agriculture and smart urban growth, and protect and restore riparian ecosystems. Shift reliance from on-stream storage to off-stream storage, resolve frost protection issues (water withdrawals), and ensure necessary flows for all life stages in all water years.

Establish a Department-coordinated staff and citizen scientist program to systematically monitor occupied stream reaches across the species' range.

Education and Enforcement

Support programs to provide educational outreach and local involvement in restoration and watershed stewardship, such as Project Wild, Adopt a Watershed, school district environmental camps, and other programs teaching the effects of human land and water use on Foothill Yellow-legged Frog survival.

Provide additional funding for increased law enforcement to reduce ecologically harmful stream alterations and water pollution and to ensure adequate protection for Foothill Yellow-legged Frogs at pumps and diversions. Identify and address illegal water diverters and out-of-compliance diverters, seasons of diversion, off-stream reservoirs, well pumping, and bypass flows to protect Foothill Yellow-legged Frogs. Prosecute violators accordingly.

ECONOMIC CONSIDERATIONS

The Department is charged in an advisory capacity in the present context to provide a written report and a related recommendation to the Commission based on the best scientific information available regarding the status of Foothill Yellow-legged Frog in California. The Department is not required to prepare an analysis of economic impacts (See Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

REFERENCES

Literature Cited

Ackerly, D., A. Jones, M. Stacey, and B. Riordan. 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.

Adams, A.J., S.J. Kupferberg, M.Q. Wilber, A.P. Pessier, M. Grefsrud, S. Bobzien, V.T. Vredenburg, and C.J. Briggs. 2017a. Extreme Drought, Host Density, Sex, and Bullfrogs Influence Fungal Pathogen Infections in a Declining Lotic Amphibian. Ecosphere 8(3):e01740. DOI: 10.1002/ecs2.1740.

Adams, A.J., A.P. Pessier, and C.J. Briggs. 2017b. Rapid Extirpation of a North American Frog Coincides with an Increase in Fungal Pathogen Prevalence: Historical Analysis and Implications for Reintroduction. Ecology and Evolution 7(23):10216-10232. DOI: 10.1002/ece3.3468

Adams, M.J., C.A. Pearl, and R.B. Bury. 2003. Indirect Facilitation of an Anuran Invasion by Non-native Fishes. Ecology Letters 6:343-351.

Allen, M., and S. Riley. 2012. Effects of Electrofishing on Adult Frogs. Unpublished report prepared by Normandeau Associates, Inc., Arcata, CA.

Alpers, C.N., M.P. Hunerlach, J.T. May, R.L. Hothem, H.E. Taylor, R.C. Antweiler, J.F. De Wild, and D.A. Lawler. 2005. Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999–2001: U.S. Geological Survey Scientific Investigations Report 2004-5251.

Alston, J.M., J.T. Lapsley, and O. Sambucci. 2018. Grape and Wine Production in California. Pp. 1-28 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/a1/1e/a11eb90f-af2a-4deb-ae58-9af60ce6aa40/grape_and_wine_production.pdf

American Bankers Association [ABA]. 2019. Marijuana and Banking. Website accessed on April 5, 2019 at https://www.aba.com/advocacy/issues/pages/marijuana-banking.aspx

Ashton, D.T. 2002. A Comparison of Abundance and Assemblage of Lotic Amphibians in Late-Seral and Second-Growth Redwood Forests in Humboldt County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Ashton, D.T., J.B. Bettaso, and H.H. Welsh, Jr. 2010. Foothill Yellow-legged Frog (*Rana boylii*) Distribution and Phenology Relative to Flow Management on the Trinity River. Oral presentation provided at the Trinity River Restoration Program's 2010 Trinity River Science Symposium 13 January 2010. http://www.trrp.net/library/document/?id=410

Ashton, D.T., A.J. Lind, and K.E. Schlick. 1997. Foothill Yellow-Legged Frog (*Rana boylii*) Natural History. USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA.

Ashton, D.T., and R.J. Nakamoto. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 38(4):442.

Baird, S.F. 1854. Descriptions of New Genera and Species of North American Frogs. Proceedings of the Academy of Natural Sciences of Philadelphia 7:62.

Bar-Massada, A., V.C. Radeloff, and S.I. Stewart. 2014. Biotic and Abiotic Effects of Human Settlements in the Wildland–Urban Interface. BioScience 64(5):429–437.

Bauer S.D., J.L. Olson, A.C. Cockrill, M.G. van Hattem, L.M. Miller, M. Tauzer, and G. Leppig. 2015. Impacts of Surface Water Diversions for Marijuana-Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLoS ONE 10(3):e0120016. https://doi.org/10.1371/journal.pone.0120016

Bee, M.A., and E.M. Swanson. 2007. Auditory Masking of Anuran Advertisement Calls by Road Traffic Noise. Animal Behaviour 74:1765-1776.

Beebee, T.J.C. 1995. Amphibian Breeding and Climate. Nature 374:219-220.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing in the Riparian Zone: Impact and Management Perspectives. Pp. 184-189 *In* R.D. Johnson and J.F. McCormick (Technical Coordinators). Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, U.S. Department of Agriculture, Forest Service, General Technical Report WO-12.

Belsky, A.J, A. Matzke, and S. Uselman. 1999. Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States. Journal of Soil and Water Conservation 54(1):419-431.

Blaustein, A.R., D.G. Hokit, R.K. O'Hara and R.A. Holt. 1994. Pathogenic Fungus Contributes to Amphibian Losses in the Pacific Northwest. Biological Conservation 67(3):251-254.

Bobzien, S., and J.E. DiDonato. 2007. The Status of the California Tiger Salamander (*Ambystoma californiense*), California Red-Legged Frog (*Rana draytonii*), Foothill Yellow-Legged Frog (*Rana boylii*), and Other Aquatic Herpetofauna in the East Bay Regional Park District, California. Unpublished report. East Bay Regional Park District, Oakland, CA.

Bondi, C.A., S.M. Yarnell, and A.J. Lind. 2013. Transferability of Habitat Suitability Criteria for a Stream Breeding Frog (*Rana boylii*) in the Sierra Nevada, California. Herpetological Conservation and Biology 8(1):88-103.

Bourque, R.M. 2008. Spatial Ecology of an Inland Population of the Foothill Yellow-Legged Frog (*Rana boylii*) in Tehama County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Bourque, R.M., and J.B. Bettaso. 2011. *Rana boylii* (Foothill Yellow-legged Frogs). Reproduction. Herpetological Review 42(4):589.

Brattstrom, B.H. 1962. Thermal Control of Aggregation Behavior in Tadpoles. Herpetologica 18(1):38-46.

Breedvelt, K.G.H., and M.J. Ellis. 2018. Foothill Yellow-legged Frog (*Rana boylii*) Growth, Longevity, and Population Dynamics from a 9-Year Photographic Capture-Recapture Study. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Brehme, C.S., S.A. Hathaway, and R.N. Fisher. 2018. An Objective Road Risk Assessment Method for Multiple Species: Ranking 166 Reptiles and Amphibians in California. Landscape Ecology 33:911-935. DOI: 10.1007/s10980-018-0640-1

Brode, J.M., and R.B. Bury. 1984. The Importance of Riparian Systems to Amphibians and Reptiles. Pp. 30-36 *In* R. E. Warner and K. M. Hendrix (Editors). Proceedings of the California Riparian Systems Conference, University of California, Davis.

Bursey, C.R., S.R. Goldberg, and J.B. Bettaso. 2010. Persistence and Stability of the Component Helminth Community of the Foothill Yellow-Legged Frog, *Rana boylii* (Ranidae), from Humboldt County, California, 1964–1965, Versus 2004–2007. The American Midland Naturalist 163(2):476-482. https://doi.org/10.1674/0003-0031-163.2.476

Burton, C.A., T.M. Hoefen, G.S. Plumlee, K.L. Baumberger, A.R. Backlin, E. Gallegos, and R.N. Fisher. 2016. Trace Elements in Stormflow, Ash, and Burned Soil Following the 2009 Station Fire in Southern California. PLoS ONE 11(5):e0153372. DOI: 10.1371/journal.pone.0153372

Bury, R.B. 1972. The Effects of Diesel Fuel on a Stream Fauna. California Department of Fish and Game Bulletin 58:291-295.

Bury, R.B., and N.R. Sisk. 1997. Amphibians and Reptiles of the Cow Creek Watershed in the BLM-Roseburg District. Draft report submitted to BLM-Roseburg District and Oregon Department of Fish and Wildlife-Roseburg. Biological Resources Division, USGS, Corvallis, OR.

Butsic, V., and J.C. Brenner. 2016. Cannabis (*Cannabis sativa* or *C. indica*) Agriculture and the Environment: A Systematic, Spacially-explicit Survey and Potential Impacts. Environmental Research Letters 11(4):044023.

California Department of Fish and Wildlife [CDFW]. 2018a. Considerations for Conserving the Foothill Yellow-Legged Frog. California Department of Fish and Wildlife; 5/14/2018. http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=157562

California Department of Fish and Wildlife [CDFW]. 2018b. Green Diamond Resource Company Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-026-01. Northern Region, Eureka, CA.

California Department of Fish and Wildlife [CDFW]. 2018c. Humboldt Redwood Company Foothill Yellow-legged Frog Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-039-01. Northern Region, Eureka, CA.

California Department of Food and Agriculture [CDFA]. 2018. California Grape Acreage Report, 2017 Summary.
https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Acreage/2018/201804grpacSUMMARY.pdf

California Department of Forestry and Fire Protection [CAL FIRE]. 2019. Top 20 Largest California Wildfires. http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf

California Department of Pesticide Regulation [CDPR]. 2018. The Top 100 Sites Used by Pounds of Active Ingredients Statewide in 2016 (All Pesticides Combined).
https://www.cdpr.ca.gov/docs/pur/pur16rep/top_100_sites_lbs_2016.pdf

California Department of Water Resources [CDWR]. 2016. Drought and Water Year 2016: Hot and Dry Conditions Continue. 2016 California Drought Update.

California Natural Resources Agency [CNRA]. 2016. Safeguarding California: Implementation Action Plan. California Natural Resources Agency.
http://resources.ca.gov/docs/climate/safeguarding/Safeguarding%20California-Implementation%20Action%20Plans.pdf

California Secretary of State [CSOS]. 2016. Proposition 64 Marijuana Legalization Initiative Statute, Analysis by the Legislative Analyst.

California Water Commission [CWC]. 2019. Proposition 1 Water Storage Investment Program: Funding the Public Benefits of Water Storage Projects. Website accessed April 5, 2019 at https://cwc.ca.gov/Water-Storage

Carah, J.K., J.K. Howard, S.E. Thompson, A.G. Short Gianotti, S.D. Bauer, S.M. Carlson, D.N. Dralle, M.W. Gabriel, L.L. Hulette, B.J. Johnson, C.A. Knight, S.J. Kupferberg, S.L. Martin, R.L. Naylor, and M.E. Power. 2015. High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization. BioScience 65(8):822-829. DOI: 10.1093/biosci/biv083

Case, M.J., J.J. Lawler, and J.A. Tomasevic. 2015. Relative Sensitivity to Climate Change of Species in Northwestern North America. Biological Conservation 187:127-133.

Catenazzi, A., and S.J. Kupferberg. 2013. The Importance of Thermal Conditions to Recruitment Success in Stream-Breeding Frog Populations Distributed Across a Productivity Gradient. Biological Conservation 168:40-48.

Catenazzi, A., and S.J. Kupferberg. 2017. Variation in Thermal Niche of a Declining River-breeding Frog: From Counter-Gradient Responses to Population Distribution Patterns. Freshwater Biology 62:1255-1265.

Catenazzi, A., and S.J. Kupferberg. 2018. Consequences of Dam-Altered Thermal Regimes for a Riverine Herbivore's Digestive Efficiency, Growth and Vulnerability to Predation. Freshwater Biology 63(9):1037-1048. DOI: 10.1111/fwb.13112

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent Changes Towards Earlier Springs: Early Signs of Climate Warming in Western North America? Watershed Management Council Networker (Spring):3-7.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate Change Scenarios for the California Region. Climatic Change 87 (Supplement 1):21-42. DOI: 10.1007/s10584-007-9377-6

Climate Change Science Program [CCSP]. 2008. Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. *In* T.R. Karl, G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (Editors). Department of Commerce, NOAA's National Climate Data Center, Washington, DC.

Conlon, J.M., A. Sonnevend, M. Patel, C. Davidson, P.F. Nielsen, T. Pál, and L.A. Rollins-Smith. 2003. Isolation of Peptides of the Brevinin-1 Family with Potent Candidacidal Activity from the Skin Secretions of the Frog *Rana boylii*. The Journal of Peptide Research 62:207-213.

Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains. Science Advances 1(1):e1400082. DOI: 10.1126/sciadv.1400082

Cook, D.G., S. White, and P. White. 2012. *Rana boylii* (Foothill Yellow-legged Frog) Upland Movement. Herpetological Review 43(2):325-326.

Cordone, A.J., and D.W. Kelley. 1961. The Influence of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game 47(2):189-228.

Crayon, J.J. 1998. *Rana catesbeiana* (Bullfrog). Diet. Herpetological Review 29(4):232.

Davidson, C. 2004. Declining Downwind: Amphibian Population Declines in California and Historical Pesticide Use. Ecological Applications 14(6):1892-1902.

Davidson, C., H.B. Shaffer, and M.R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B, and Climate-Change Hypotheses for California Amphibian Declines. Conservation Biology 16(6):1588-1601.

Davidson, C., M.F. Benard, H.B. Shaffer, J.M. Parker, C. O'Leary, J.M. Conlon, and L.A. Rollins-Smith. 2007. Effects of Chytrid and Carbaryl Exposure on Survival, Growth and Skin Peptide Defenses in Foothill Yellow-legged Frogs. Environmental Science and Technology 41(5):1771-1776. DOI: 10.1021/es0611947

Dawson, T.P., S.T. Jackson, J.I. House, I.C. Prentice, and G.M. Mace. 2011. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science 332:53-58.

Dettinger, M., H. Alpert, J. Battles, J. Kusel, H. Safford, D. Fougeres, C. Knight, L. Miller, and S. Sawyer. 2018. Sierra Nevada Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004.

Dever, J.A. 2007. Fine-scale Genetic Structure in the Threatened Foothill Yellow-legged Frog (*Rana boylii*). Journal of Herpetology 41(1):168-173.

Dillingham, C.P., C.W. Koppl, J.E. Drennan, S.J. Kupferberg, A.J. Lind, C.S. Silver, T.V. Hopkins, K.D. Wiseman, and K.R. Marlow. 2018. *In Situ* Population Enhancement of an At-Risk Population of Foothill Yellow-legged Frogs, *Rana boylii*, in the North Fork Feather River, Butte County, California. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Doubledee, R.A., E.B. Muller, and R.M. Nisbet. 2003. Bullfrogs, Disturbance Regimes, and the Persistence of California Red-legged Frogs. Journal of Wildlife Management 67(2):424-438.

Drennan, J.E., K.A. Marlow, K.D. Wiseman, R.E. Jackman, I.A. Chan, and J.L. Lessard. 2015. *Rana boylii* Aging: A Growing Concern. Abstract of paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 8-10 January 2015, Malibu, CA.

Drost, C.A., and G.M. Fellers. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. Conservation Biology 10(2):414-425.

East Contra Costa County Habitat Conservancy [ECCCHC]. 2018. East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan Annual Report 2017.

Ecoclub Amphibian Group, K.L. Pope, G.M. Wengert, J.E. Foley, D.T. Ashton, and R.G. Botzler. 2016. Citizen Scientists Monitor a Deadly Fungus Threatening Amphibian Communities in Northern Coastal California, USA. Journal of Wildlife Diseases 52(3):516-523.

El Dorado Irrigation District [EID]. 2007. Project 184 Foothill Yellow-legged Frog Monitoring Plan.

Electric Consumers Protection Act [ECPA]. 1986. 16 United States Code § 797, 803.

Eriksson A., F. Elías-Wolff, B. Mehlig, and A. Manica. 2014. The Emergence of the Rescue Effect from Explicit Within- and Between-Patch Dynamics in a Metapopulation. Proceedings of the Royal Society B 281:20133127. http://dx.doi.org/10.1098/rspb.2013.3127

Evenden, F.G., Jr. 1948. Food Habitats of *Triturus granulosus* in Western Oregon. Copeia 1948(3):219-220.

Fahrig, L., and G. Merriam. 1985. Habitat Patch Connectivity and Population Survival. Ecology 66(6):1762-1768.

Federal Energy Regulatory Commission [FERC]. 2007a. Order Issuing New License, Project No. 233-081.

Federal Energy Regulatory Commission [FERC]. 2007b. Relicensing Settlement Agreement for the Upper American River Project and Chili Bar Hydroelectric Project.

Federal Energy Regulatory Commission [FERC]. 2009a. Order Amending Forest Service 4(e) Condition 5A, Project No. 1962-187.

Federal Energy Regulatory Commission [FERC]. 2009b. Order Issuing New License, Project No. 2130-033.

Federal Energy Regulatory Commission [FERC]. 2014. Order Issuing New License, Project No. 2101-084.

Federal Energy Regulatory Commission [FERC]. 2018. Final Environmental Impact Statement. Lassen Lodge Hydroelectric Project. Project No. 12496-002.

Federal Energy Regulatory Commission [FERC]. 2019. Active Licenses. FERC eLibrary. Accessed March 10, 2019. https://www.ferc.gov/industries/hydropower/gen-info/licensing/active-licenses.xls

Fellers, G.M. 2005. *Rana boylii* Baird, 1854(b). Pp. 534-536 *In* M. Lannoo (Editor). Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.

Ferguson, E. 2019. Cultivating Cooperation: Pilot Study Around Headwaters of Mattole River Considers the Effect of Legal Cannabis Cultivators on Northern California Watersheds. Outdoor California 79(1):22-29.

Fidenci, P. 2006. *Rana boylii* (Foothill Yellow-legged Frog) Predation. Herpetological Review 37(2):208.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting Climate Change in California. Ecological Impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, MA, and the Ecological Society of America, Washington, DC.

Fisher, R.N., and H.B. Shaffer. 1996. The Decline of Amphibians in California's Great Central Valley. Conservation Biology 10(5):1387-1397.

Fitch, H.S. 1936. Amphibians and Reptiles of the Rogue River Basin, Oregon. The American Midland Naturalist 17(3):634-652.

Fitch, H.S. 1938. *Rana boylii* in Oregon. Copeia 1938(3):148.

Fitch, H.S. 1941. The Feeding Habits of California Garter Snakes. California Fish and Game 27(2):1-32.

Florsheim, J.L., A. Chin, A.M. Kinoshita, and S. Nourbakhshbeidokhti. 2017. Effect of Storms During Drought on Post-Wildfire Recovery of Channel Sediment Dynamics and Habitat in the Southern California Chaparral, USA. Earth Surface Processes and Landforms 42(1):1482-1492. DOI: 10.1002/esp.4117.

Foe, C.G., and B. Croyle. 1998. Mercury Concentration and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary. Staff report, California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone Hazards to Amphibians and Reptiles. Herpetological Review 25(4):150-153, 156.

Fox, W. 1952. Notes on the Feeding Habits of Pacific Coast Garter Snakes. Herpetologica 8(1):4-8.

Fuller, D.D., and A.J. Lind. 1992. Implications of Fish Habitat Improvement Structures for Other Stream Vertebrates. Pp. 96-104 *In* Proceedings of the Symposium on Biodiversity of Northwestern California. R. Harris and D. Erman (Editors). Santa Rosa, CA.

Fuller, T.E., K.L. Pope, D.T. Ashton, and H.H. Welsh. 2011. Linking the Distribution of an Invasive Amphibian (*Rana catesbeiana*) to Habitat Conditions in a Managed River System in Northern California. Restoration Ecology 19(201):204-213. DOI: 10.1111/j.1526-100X.2010.00708.x

Furey, P.C., S.J. Kupferberg, and A.J. Lind. 2014. The Perils of Unpalatable Periphyton: *Didymosphenia* and Other Mucilaginous Stalked Diatoms as Food for Tadpoles. Diatom Research 29(3):267-280.

Gaos, A., and M. Bogan. 2001. A Direct Observation Survey of the Lower Rubicon River. California Department of Fish and Game, Rancho Cordova, CA.

Garcia and Associates [GANDA]. 2008. Identifying Microclimatic and Water Flow Triggers Associated with Breeding Activities of a Foothill Yellow-Legged Frog (*Rana boylii*) Population on the North Fork Feather River, California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-041.

Garcia and Associates [GANDA]. 2017. 2016 Surveys for Foothill Yellow-legged Frog El Dorado County, California for the El Dorado Hydroelectric Project (FERC No. 184) – Job 642-9. Prepared for El Dorado Irrigation District, San Francisco, CA.

Garcia and Associates [GANDA]. 2018. Draft Results of 2017 Surveys for Foothill Yellow-legged Frog (*Rana boylii*) on the Cresta and Poe Reaches of the North Fork Feather River – Job 708/145. Prepared for Pacific Gas and Electric Company, San Francisco, CA.

Geisseler, D., and W.R. Horwath. 2016. Grapevine Production in California. A collaboration between the California Department of Food and Agriculture; Fertilization Education and Research, Project; and University of California, Davis.
https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Grapevine_Production_CA.pdf

Gibbs, J.P., and A.R. Breisch. 2001. Climate Warming and Calling Phenology of Frogs Near Ithaca, New York, 1900-1999. Conservation Biology 15(4):1175-1178.

Gomulkiewicz, R., and R.D. Holt. 1995. When Does Evolution by Natural Selection Prevent Extinction? Evolution 49(1):201-207.

Gonsolin, T.T. 2010. Ecology of Foothill Yellow-legged Frogs in Upper Coyote Creek, Santa Clara County, CA. Master's Thesis. San Jose State University, San Jose, CA.

Grantham, T. E., A. M. Merenlender, and V. H. Resh. 2010. Climatic Influences and Anthropogenic Stressors: An Integrated Framework for Stream Flow Management in Mediterranean-climate California, U.S.A. Freshwater Biology 55(Supplement 1):188-204. DOI: 10.1111/j.1365-2427.2009.02379.x

Green, D.M. 1986a. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Karyological Evidence. Systematic Zoology 35(3):273-282.

Green, D.M. 1986b. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Electrophoretic Evidence. Systematic Zoology 35(3):283-296.

Green Diamond Resource Company [GDRC]. 2018. Mad River Foothill Yellow-legged Frog Egg Mass Surveys Summary Humboldt County, California. Progress report to the California Department of Fish and Wildlife, Wildlife Branch-Nongame Wildlife Program, pursuant to the requirements of Scientific Collecting Permit Entity #6348.

Griffin, D., and K.J. Anchukaitis. 2014. How Unusual is the 2012-2014 California Drought? Geophysical Research Letters 41: 9017-9023. DOI: 10.1002/2014GL062433.

Grinnell, J., and T. I. Storer. 1924. Animal Life in the Yosemite: An Account of the Mammals, Birds, Reptiles, and Amphibians in a Cross-section of the Sierra Nevada. University of California Press, Berkeley, CA.

Grinnell, J., J. Dixon, and J.M. Linsdale. 1930. Vertebrate Natural History of a Section of Northern California Through the Lassen Peak Region. University of California Press, Berkeley, CA.

Haggarty, M. 2006. Habitat Differentiation and Resource Use Among Different Age Classes of Post Metamorphic *Rana boylii* on Red Bank Creek, Tehama County, California. Master's Thesis. Humboldt State University, Arcata, CA.

Harvey, B.C., and T.E. Lisle. 1998. Effects of Suction Dredging on Streams: A Review and an Evaluation Strategy. Fisheries 23(8):8-17.

Hayes, M.P., and M.R. Jennings. 1986. Decline of Ranid Frog Species in Western North America: Are Bullfrogs (*Rana catesbeiana*) Responsible? Journal of Herpetology 20(4):490-509.

Hayes, M.P., and M.R. Jennings. 1988. Habitat Correlates of Distribution of the California Red-legged Frog (*Rana aurora draytonii*) and the Foothill Yellow-Legged Frog (*Rana boylii*): Implications for Management. Pp. 144-158 *In* Management of Amphibians, Reptiles, and Small Mammals in North America, General Technical Report. RM-166 R.C. Szaro, K.E. Severson, and D.R. Patton (Technical Coordinators). USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hayes, M.P., C.A. Wheeler, A.J. Lind, G.A. Green, and D.C. Macfarlane (Technical Coordinators). 2016. Foothill Yellow-Legged Frog Conservation Assessment in California. Gen. Tech. Rep. PSW-GTR-248. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffle, and A. Vonk. 2003. Atrazine-induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence. Environmental Health Perspectives 11(4):568-575.

Hayes, T.B., P. Case, S. Chui, D. Chung, C. Haeffele, K. Haston, M. Lee, V. P. Mai, Y. Marjuoa, J. Parker, and M. Tsui. 2006. Pesticide Mixtures, Endocrine Disruption, and Amphibian Declines: Are We Underestimating the Impact? Environmental Health Perspectives 114(Supplement 1):40-50.

Hemphill, D.V. 1952. The Vertebrate Fauna of the Boreal Areas of the Southern Yolla Bolly Mountains, California. PhD Dissertation. Oregon State University, Corvallis.

Hillis, D.M., and T.P. Wilcox. 2005. Phylogeny of the New World true frogs (*Rana*). Molecular Phylogenetics and Evolution 34:299-314.

Hoffmann, A.A., and C.M. Sgrò. 2011. Climate Change and Evolutionary Adaptation. Nature 470:479-485. https://www.nature.com/articles/nature09670

Hogan, S., and C. Zuber. 2012. North Fork American River 2012 Summary Report. California Department of Fish and Wildlife Heritage and Wild Trout Program, Rancho Cordova, CA.

Hopkins, G.R., S.S. French, and E.D. Brodie. 2013. Increased Frequency and Severity of Developmental Deformities in Rough-skinned Newt (*Taricha granulosa*) Embryos Exposed to Road Deicing Salts (NaCl & $MgCl_2$). Environmental Pollution 173:264-269. http://dx.doi.org/10.1016/j.envpol.2012.10.002

Hothem, R.L., A.M. Meckstroth, K.E. Wegner, M.R. Jennings, and J.J. Crayon. 2009. Diets of Three Species of Anurans from the Cache Creek Watershed, California, USA. Journal of Herpetology 43(2):275-283.

Hothem, R.L., M.R. Jennings, and J.J. Crayon. 2010. Mercury Contamination in Three Species of Anuran Amphibians from the Cache Creek Watershed, California, USA. Environmental Monitoring and Assessment 163:433-448. https://doi.org/10.1007/s10661-009-0847-3

Humboldt Redwoods Company [HRC]. 2015. Habitat Conservation Plan for the Properties of The Pacific Lumber Company, Scotia Pacific Holding Company, and Salmon Creek Corporation under the Ownership and Management of Humboldt Redwood Company, LLC, as of July 2008. Established February 1999, Revised 12 August 2015.

ICF International. 2012. Final Santa Clara Valley Habitat Plan. https://scv-habitatagency.org/178/Santa-Clara-Valley-Habitat-Plan

Jackman, R.E., J.E. Drennan, K.R. Marlow, and K.D. Wiseman. 2004. Some Effects of Spring and Summer Pulse Flows on River-breeding Foothill Yellow-legged Frogs (*Rana boylii*) along the North Fork Feather

River. Abstract of paper presented at the Cal-Neva and Humboldt Chapters of the American Fisheries Society Annual Meeting 23 April 2004, Redding, CA.

Jennings, M.R., and M.P. Hayes. 1985. Pre-1900 Overharvest of California Red-Legged Frogs (*Rana aurora draytonii*): The Inducement for Bullfrog (*Rana catesbeiana*) Introduction. Herpetologica 41(1):94-103.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Contract No. 8023. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA.

Jennings, M.R., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Coloration. Herpetological Review 36(4):438.

Jones & Stokes Associates. 2006. East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan.

Karraker, N.E., J.P. Gibbs, and J.R. Vonesh. 2008. Impacts of Road Deicing Salt on the Demography of Vernal Pool-breeding Amphibians. Ecological Applications 18(3):724-734.

Kats, L.B., and R.P. Ferrer. 2003. Alien Predators and Amphibian Declines: Review of Two Decades of Science and the Transition to Conservation. Diversity and Distributions 9(2):99-110.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streambank Management Implications…A review. Journal of Range Management 37(5):430-437.

Kauffman, J.B., W.C. Krueger, and M. Varva. 1983. Impacts of Cattle on Streambanks in Northeastern Oregon. Journal of Range Management 36(6):683-685.

Keeley, J.E. 2005. Fire History of the San Francisco East Bay Region and Implications for Landscape Patterns. International Journal of Wildland Fire 14:285-296.

Keeley, J.E., and A.D. Syphard. 2016. Climate Change and Future Fire Regimes: Examples from California. Geosciences 6(7):37. DOI: 10.3390/geosciences6030037

Kerby, J.L., and A. Sih. 2015. Effects of Carbaryl on Species Interactions of the Foothill Yellow Legged Frog (*Rana boylii*) and the Pacific Treefrog (*Pseudacris regilla*). Hydrobiologia 746(1):255-269. DOI: 10.1007/s10750-014-2137-5

Kiesecker, J.M. 2002. Synergism Between Trematode Infection and Pesticide Exposure: A Link to Amphibian Limb Deformities in Nature? PNAS 99(15):9900-9904. https://doi.org/10.1073/pnas.152098899

Kiesecker, J.M., and A.R. Blaustein. 1997. Influences of Egg Laying Behavior on Pathogenic Infection of Amphibian Eggs. Conservation Biology 11(1):214-220.

Knowles, N., M.D. Dettinger, and D.R. Cayan. 2006. Trends in Snowfall Versus Rainfall in the Western United States. Journal of Climate 19(18):4545-4559. https://doi.org/10.1175/JCLI3850.1

Kupferberg, S.J. 1996a. Hydrologic and Geomorphic Factors Affecting Conservation of a River-Breeding Frog (*Rana boylii*). Ecological Applications 6(4):1322-1344.

Kupferberg, S.J. 1996b. The Ecology of Native Tadpoles (*Rana boylii* and *Hyla regilla*) and the Impact of Invading Bullfrogs (*Rana catesbeiana*) in a Northern California River. PhD Dissertation. University of California, Berkeley.

Kupferberg, S.J. 1997a. Bullfrog (*Rana catesbeiana*) Invasion of a California River: The Role of Larval Competition. Ecology 78(6):1736-1751.

Kupferberg, S.J. 1997b. The Role of Larval Diet in Anuran Metamorphosis. American Zoology 37:146-159.

Kupferberg, S., and A. Catenazzi. 2019. Between Bedrock and a Hard Place: Riverine Frogs Navigate Tradeoffs of Pool Permanency and Disease Risk During Drought. Abstract prepared for the Joint Meeting of Ichthyologists and Herpetologists. 24-28 July 2019, Snowbird, UT.

Kupferberg, S.J., A. Catenazzi, K. Lunde, A. Lind, and W. Palen. 2009a. Parasitic Copepod (*Lernaea cyprinacea*) Outbreaks in Foothill Yellow-legged Frogs (*Rana boylii*) Linked to Unusually Warm Summers and Amphibian Malformations in Northern California. Copeia 2009(3):529-537.

Kupferberg, S.J., A. Catenazzi, and M.E. Power. 2011a. The Importance of Water Temperature and Algal Assemblage for Frog Conservation in Northern California Rivers with Hydroelectric Projects. Final Report to the California Energy Commission, PIER. CEC-500-2014-033.

Kupferberg, S.J., and P.C. Furey. 2015. An Independent Impact Analysis using Carnegie State Vehicular Recreation Area Habitat Monitoring System Data. Friends of Tesla Park Technical Memorandum. DOI: 10.13140/RG.2.1.4898.9207

Kupferberg, S.J., A. Lind, J. Mount, and S. Yarnell. 2009b. Pulsed Flow Effects on the Foothill Yellow-Legged Frog (*Rana boylii*): Integration of Empirical, Experimental, and Hydrodynamic Modeling Approaches. Final Report. California Energy Commission, PIER. CEC-500-2009-002.

Kupferberg, S.J, A.J. Lind, and W.J. Palen. 2009c. Pulsed Flow Effects on the Foothill Yellow-legged Frog (*Rana boylii*): Population Modeling. Final Report to the California Energy Commission, PIER. CEC-500-2009-002a.

Kupferberg, S.J., A.J. Lind, V. Thill, and S.M. Yarnell. 2011b. Water Velocity Tolerance in Tadpoles of the Foothill Yellow-legged Frog (*Rana boylii*): Swimming Performance, Growth, and Survival. Copeia 2011(1):141-152.

Kupferberg, S.J., W.J. Palen, A.J. Lind, S. Bobzien, A. Catenazzi, J. Drennan, and M.E. Power. 2012. Effects of Flow Regimes Altered by Dams on Survival, Population Declines, and Range-wide Losses of California River-Breeding Frogs. Conservation Biology 26(3):513-524.

Lambert, M.R., T. Tran, A. Kilian, T. Ezaz, and D.K. Skelly. 2019. Molecular Evidence for Sex Reversal in Wild populations of Green Frogs (*Rana clamitans*). PeerJ 7:e6449. DOI: 10.7717/peerj.6449

Lande, R., and S. Shannon. 1996. The Role of Genetic Variation in Adaptation and Population Persistence in a Changing Environment. Evolution 50(1):434-437.

Leidy, R.A., E. Gonsolin, and G.A. Leidy. 2009. Late-summer Aggregation of the Foothill Yellow-legged Frog (*Rana boylii*) in Central California. The Southwestern Naturalist 54(3):367-368.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, and J.N. Seiber. 1999. Summertime Transport of Current-Use Pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. Environmental Toxicology and Chemistry 18(12):2715-2722.

Lind, A.J. 2005. Reintroduction of a Declining Amphibian: Determining an Ecologically Feasible Approach for the Foothill Yellow-legged Frog (*Rana boylii*) Through Analysis of Decline Factors, Genetic Structure, and Habitat Associations. PhD Dissertation. University of California, Davis.

Lind, A.J., J.B. Bettaso, and S.M. Yarnell. 2003a. Natural History Notes: *Rana boylii* (Foothill Yellow-legged Frog) and *Rana catesbeiana* (Bullfrog). Reproductive behavior. Herpetological Review 34(3):234-235.

Lind, A.J., L. Conway, H. (Eddinger) Sanders, P. Strand, and T. Tharalson. 2003b. Distribution, Relative Abundance, and Habitat of Foothill Yellow-legged Frogs (*Rana boylii*) on National Forests in the Southern Sierra Nevada Mountains of California. Report to the FHR Program of Region 5 of the USDA Forest Service.

Lind, A.J., P.Q. Spinks, G.M. Fellers, and H.B. Shaffer. 2011. Rangewide Phylogeography and Landscape Genetics of the Western U.S. Endemic Frog *Rana boylii* (Ranidae): Implications for the Conservation of Frogs and Rivers. Conservation Genetics 12:269-284.

Lind, A.J., and H.H. Welsh, Jr. 1994. Ontogenetic Changes in Foraging Behaviour and Habitat Use by the Oregon Garter Snake, *Thamnophis atratus hydrophilus*. Animal Behaviour 48:1261-1273.

Lind, A.J., H.H. Welsh, Jr., and C.A. Wheeler. 2016. Foothill Yellow-legged Frog (*Rana boylii*) Oviposition Site Choice at Multiple Spatial Scales. Journal of Herpetology 50(2):263-270.

Lind, A.J., H.H. Welsh, Jr., and R.A. Wilson. 1996. The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii*) in Northwestern California. Herpetological Review 27(2):62-67.

Little, E.E., and R.D. Calfee. 2000. The Effects of UVB Radiation on the Toxicity of Fire-Fighting Chemicals. Final Report. U.S. Geological Service, Columbia Environmental Research Center, Columbia, MO.

Loomis, R.B. 1965. The Yellow-legged Frog, *Rana boylei*, from the Sierra San Pedro Mártir, Baja California Norte, México. Herpetologica 21(1):78-80.

Lowe, J. 2009. Amphibian Chytrid (*Batrachochytrium dendrobatidis*) in Postmetamorphic *Rana boylii* in Inner Coast Ranges of Central California. Herpetological Review 40(2):180.

Macey, R.J., J.L. Strasburg, J.A. Brisson, V.T. Vredenburg, M. Jennings, and A. Larson. 2001. Molecular Phylogenetics of Western North American Frogs of the *Rana boylii* Species Group. Molecular Phylogenetics and Evolution 19(1):131-143.

MacTague, L., and P.T. Northen. 1993. Underwater Vocalization by the Foothill Yellow-Legged Frog (*Rana boylii*). Transactions of the Western Section of the Wildlife Society 29:1-7.

Mallakpour, I., M. Sadegh, and A. AghaKouchak. 2018. A New Normal for Streamflow in California in a Warming Climate: Wetter Wet Seasons and Drier Dry Seasons. Journal of Hydrology 567:203-211.

Mallery, M. 2010. Marijuana National Forest: Encroachment on California Public Lands for Cannabis Cultivation. Berkeley Undergrad Journal 23(2):1-50. http://escholarship.org/uc/item/7r10t66s#page-2

Marlow, C.B., and T.M. Pogacnik. 1985. Time of Grazing and Cattle-Induced Damage to Streambanks. Pp. 279-284 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Marlow, K.R., K.D. Wiseman, C.A. Wheeler, J.E. Drennan, and R.E. Jackman. 2016. Identification of Individual Foothill Yellow-legged Frogs (*Rana boylii*) using Chin Pattern Photographs: A Non-Invasive and Effective Method for Small Population Studies. Herpetological Review 47(2):193-198.

Martin, C. 1940. A New Snake and Two Frogs for Yosemite National Park. Yosemite Nature Notes 19(11):83-85.

Martin, P.L., R.E. Goodhue, and B.D. Wright. 2018. Introduction. Pp. 1-25 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/07/5c/075c8120-3705-4a79-ae74-130fdfe46c6b/introduction.pdf

McCartney-Melstad, E., M. Gidiş, and H.B. Shaffer. 2018. Population Genomic Data Reveal Extreme Geographic Subdivision and Novel Conservation Actions for the Declining Foothill Yellow-legged Frog. Heredity 121:112-125.

Megahan, W.F., J.G. King, and K.A. Seyedbagheri. 1995. Hydrologic and Erosional Responses of a Granitic Watershed to Helicopter Logging and Broadcast Burning. Forest Science 41(4):777-795.

Merenlender, A.M. 2000. Mapping Vineyard Expansion Provides Information on Agriculture and the Environment. California Agriculture 54(3):7-12.

Mierau, D.W., W.J. Trush, G.J. Rossi, J.K. Carah, M.O. Clifford, and J.K. Howard. 2017. Managing Diversions in Unregulated Streams using a Modified Percent-of-Flow Approach. Freshwater Biology 63:752-768. DOI: 10.1111/fwb.12985

Moyle, P.B. 1973. Effects of Introduced Bullfrogs, *Rana catesbeiana*, on the Native Frogs of the San Joaquin Valley, California. Copeia 1973(1):18-22.

Moyle, P.B., and P.J. Randall. 1998. Evaluating the Biotic Integrity of Watersheds in the Sierra Nevada, California. Conservation Biology 12(6):1318-1326.

Napa County. 2010. Napa County Voluntary Oak Woodlands Management Plan.

National Integrated Drought Information System [NIDIS]. 2019. Drought in California from 2000-2019. National Drought Mitigation Center, U.S. Department of Agriculture Federal Drought Assistance. Accessed 25 April 2019 at https://www.drought.gov/drought/states/california

National Marine Fisheries Service [NMFS]. 2012. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office, Sacramento, CA.

National Marine Fisheries Service [NMFS]. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, CA.

Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians & Reptiles of the Pacific Northwest. University Press of Idaho, Moscow, ID.

Off-Highway Motor Vehicle Recreation Commission [OHMVRC]. 2017. Off-Highway Motor Vehicle Recreation Commission Program Report, January 2017. http://ohv.parks.ca.gov/pages/1140/files/OHMVR-Commission-2017-Program_Report-FINAL-Mar2017_web.pdf

Office of Environmental Health Hazard Assessment [OEHAA], California Environmental Protection Agency. 2018. Indicators of Climate Change in California. https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

Olson, D.H., and R. Davis. 2009. Conservation Assessment for the Foothill Yellow-legged Frog (*Rana boylii*) in Oregon. USDA Forest Service Region 6 and USDI Bureau of Land Management Interagency Special Status Species Program.

Olson, E.O., J.D. Shedd, and T.N. Engstrom. 2016. A Field Inventory and Collections Summary of Herpetofauna from the Sutter Buttes, an "Inland Island" within California's Great Central Valley. Western North American Naturalist 76(3):352-366.

Pacific Gas and Electric [PG&E]. 2018. Pit 3, 4, and 5 Hydroelectric Project (FERC Project No. 233) Foothill Yellow-Legged Frog Monitoring 2017 Annual Report.

Padgett-Flohr, G.E., and R.L. Hopkins. 2009. *Batrachochytrium dendrobatidis*, a Novel Pathogen Approaching Endemism in Central California. Diseases of Aquatic Organisms 83:1-9.

Palstra, F.P., and D.E. Ruzzante. 2008. Genetic Estimates of Contemporary Effective Population Size: What Can They Tell Us about the Importance of Genetic Stochasticity for Wild Population Persistence? Molecular Ecology 17:3428-3447. DOI: 10.1111/j.1365-294X.2008.03842.x

Paoletti, D.J., D.H. Olson, and A.R. Blaustein. 2011. Responses of Foothill Yellow-legged Frog (*Rana boylii*) Larvae to an Introduced Predator. Copeia 2011(1):161-168.

Parks, S.A., C. Miller, J.T. Abatzoglou, L.M. Holsinger, M-A. Parisien, and S.Z. Dobrowski. 2016. How Will Climate Change Affect Wildland Fire Severity in the Western US? Environmental Research Letters 11:035002. DOI: 10.1088/1748-9326/11/3/035002

Parmesan, C., and G. Yohe. 2003. A Globally Coherent Fingerprint of Climate Change Impacts across Natural Systems. Nature 421(6918):37-42. DOI: 10.1038/nature01286

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs Call at a Higher Pitch in Traffic Noise. Ecology and Society 12(1):25. http://www.ecologyandsociety.org/vol14/iss1/art25/

Peek, R.A. 2011. Landscape Genetics of Foothill Yellow-legged Frogs (*Rana boylii*) in Regulated and Unregulated Rivers: Assessing Connectivity and Genetic Fragmentation. Master's Thesis. University of San Francisco, San Francisco, CA.

Peek, R.A. 2018. Population Genetics of a Sentinel Stream-breeding Frog (*Rana boylii*). PhD Dissertation. University of California, Davis.

Peek, R., and S. Kupferberg. 2016. Assessing the Need for Endangered Species Act Protection of the Foothill Yellow-legged Frog (*Rana boylii*): What do Breeding Censuses Indicate? Abstract of poster presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 7-8 January 2016, Davis, CA.

Pilliod, D.S., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and Amphibians in North America. Forest Ecology and Management 178:163-181.

Placer County Water Agency [PCWA]. 2008. Final AQ 12 – Special-Status Amphibian and Aquatic Reptile Technical Study Report – 2007. Placer County Water Agency Middle Fork American River Project (FERC No. 2079), Auburn, CA.

Pounds, A., A.C.O.Q. Carnaval, and S. Corn. 2007. Climate Change, Biodiversity Loss, and Amphibian Declines. Pp. 19-20 *In* C. Gascon, J.P. Collins, R.D. Moore, D.R. Church, J.E. McKay, and J.R. Mendelson III (Editors). IUCN Amphibian Conservation Action Plan, Proceedings: IUCN/SSC Amphibian Conservation Summit 2005.

Powell, R., R. Conant, and J.T. Collins. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central America, Fourth Edition.

Power, M.E., M.S. Parker, and W.E. Dietrich. 2008. Seasonal Reassembly of a River Food Web: Floods, Droughts, and Impacts of Fish. Ecological Monographs 78(2):263-282.

Prado, M. 2005. Rare Frogs Put at Risk by Visitors in West Marin. Marin Independent Journal. Newspaper article, May 09, 2005.

Public Policy Institute of California [PPIC]. 2018. Storing Water. https://www.ppic.org/publication/californias-water-storing-water/

Public Policy Institute of California [PPIC]. 2019. California's Future: Population. https://www.ppic.org/wp-content/uploads/californias-future-population-january-2019.pdf

Radeloff, V.C., D.P. Helmers, H.A. Kramer, M.H. Mockrin, P.M. Alexandre, A. Bar-Massada, V. Butsic, T.J. Hawbaker, S. Martinuzzi, A.D. Syphard, and S.I. Stewart. 2018. Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk. PNAS 115(13):3314-3319. https://doi.org/10.1073/pnas.1718850115

Railsback, S.F., B.C. Harvey, S.J. Kupferberg, M.M. Lang, S. McBain, and H.H. Welsh, Jr. 2016. Modeling Potential River Management Conflicts between Frogs and Salmonids. Canadian Journal of Fisheries and Aquatic Sciences 73:773-784.

Reeder, N.M.M., A.P. Pessier, and V.T. Vredenburg. 2012. A Reservoir Species for the Emerging Amphibian Pathogen *Batrachochytrium dendrobatidis* Thrives in a Landscape Decimated by Disease. PLoS ONE 7(3):e33567. https://doi.org/10.1371/journal.pone.0033567

Riegel, J.A. 1959. The Systematics and Distribution of Crayfishes in California. California Fish and Game 45:29-50.

Relyea, R.A. 2005. The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Ecological Applications 15(2):618-627.

Relyea, R.A., and N. Diecks. 2008. An Unforeseen Chain of Events: Lethal Effects of Pesticides on Frogs at Sublethal Concentrations. Ecological Applications 18(7):1728-1742.

Rombough, C. 2006. Winter Habitat Use by Juvenile Foothill Yellow-legged Frogs (*Rana boylii*): The Importance of Seeps. *In* Abstracts from the 2006 Annual Meetings of the Society for Northwestern Vertebrate Biology and the Washington Chapter of the Wildlife Society. Northwest Naturalist 87(2):159.

Rombough, C.J., J. Chastain, A.M. Schwab, and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(4):438-439.

Rombough, C.J., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation: Eggs and Hatchlings. Herpetological Review 36(2):163-164.

Rombough, C.J., and M.P. Hayes. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Reproduction. Herpetological Review 38(1):70-71.

Russell, K.R., D.H. Van Lear, and D.C. Guynn, Jr. 1999. Prescribed Fire Effects on Herpetofauna: Review and Management Implications. Wildlife Society Bulletin 27(2):374-384.

San Joaquin Council of Governments, Inc. [SJCOG 2018]. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2018 Annual Report.

San Joaquin County. 2000. San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan.

Santa Clara Valley Habitat Agency [SCVHA]. 2019. Santa Clara Valley Habitat Plan 4th Annual Report FY2017-2018.

Scheele, B.C., F. Pasmans, L.F. Skerratt, L. Berger, A. Martel, W. Beukema, A.A. Acevedo, P.A. Burrows, T. Carvalhos, A. Catenazzi, I. De la Riva, M.C. Fisher, S.V. Flechas, C.N. Foster, P. Frías-Álvarez, T.W.J. Garner, B. Gratwicke, J.M. Guayasamin, M. Hirschfeld, J.E. Kolby, T.A. Kosch, E. La Marca, D.B. Lindenmayer, K.R. Lips, A.V. Longo, R. Maneyro, C.A. McDonald, J. Mendelson III, P. Palacios-Rodriguez, G. Parra-Olea, C.L. Richards-Zawacki, M-O. Rödel, S.M. Rovito, C. Soto-Azat, L.F. Toledo, J. Voyles, C. Weldon, S.M. Whitfield, M. Wilkinson, K.R. Zamudio, and S. Canessa. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. Science 363(6434):1459-1463. DOI: 10.1126/science.aav0379

Siekert, R.E., Q.D. Skinner, M.A. Smith, J.L. Dodd, and J.D. Rogers. 1985. Channel Response of an Ephemeral Stream in Wyoming to Selected Grazing Treatments. Pp. 276-278 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Silver, C.S. 2017. Population-level Variation in Vocalizations of *Rana boylii*, the Foothill Yellow-legged Frog. Master's Thesis. California State University, Chico, Chico, CA.

Snover, M.L., and M.J. Adams. 2016. Herpetological Monitoring and Assessment on the Trinity River, Trinity County, California-Final Report: U.S. Geological Survey Open-File Report 2016-1089. http://dx.doi.org/10.3133/ofr20161089

Sparling, D.W., and G.M. Fellers. 2007. Comparative Toxicity of Chlorpyrifos, Diazinon, Malathion and Their Oxon Derivatives to *Rana boylii*. Environmental Pollution 147:535-539.

Sparling, D.W., and G.M. Fellers. 2009. Toxicity of Two Insecticides to California, USA, Anurans and Its Relevance to Declining Amphibian Populations. Environmental Toxicology and Chemistry 28(8):1696-1703.

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and Amphibian Declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.

Spencer, C.N., and F.R. Hauer. 1991. Phosphorus and Nitrogen Dynamics in Streams During a Wildfire. Journal of the North American Benthological Society 10(1):24-30.

Spring Rivers Ecological Sciences. 2003. Foothill Yellow-legged Frog (*Rana boylii*) Studies in 2002 for Pacific Gas and Electric Company's Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233). Pacific Gas and Electric Company, Technical and Ecological Services, San Ramon, CA.

State Board of Forestry and Fire Protection [SBFFP]. 2018. 2018 Strategic Fire Plan for California. Accessed March 1, 2019 at: http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf1614.pdf

State Water Resources Control Board [SWRCB]. 2017. Water Quality Certification for the Pacific Gas and Electric Company Poe Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2107.

State Water Resources Control Board [SWRCB]. 2018. Water Quality Certification for the South Feather Water and Power Agency South Feather Power Project, Federal Energy Regulatory Commission Project No. 2088.

State Water Resources Control Board [SWRCB]. 2019. February 2019 Executive Director's Report. Accessed February 18, 2019 at: https://www.waterboards.ca.gov/board_info/exec_dir_rpts/2019/ed_rpt_021119.pdf

Stebbins, R.C. 2003. Peterson Filed Guides Western Reptiles and Amphibians. Third Edition. Houghton Mifflin Company, Boston, MA.

Stebbins, R.C., and S.M. McGinnis. 2012. Field Guide to Amphibians and Reptiles of California. Revised Edition. University of California Press, Berkeley, CA.

Stephens, S.L., N. Burrows, A. Buyantuyev, R.W. Gray, R.E. Keane, R. Kubian, S. Liu, F. Seijo, L. Shu, K.G. Tolhurst, and J.W. van Wagtendonk. 2014. Temperate and Boreal Forest Mega-Fires: Characteristics and Challenges. Frontiers in Ecology and the Environment 12(2):115-122.

Stephens, S.L, J.D. McIver, R.E.J. Boerner, C.J. Fettig, J.B. Fontaine, B.R. Hartsough, P.I. Kennedy, and D.W. Schwilk. 2012. The Effects of Forest Fuel-Reduction Treatments in the United States. BioScience 62(6):549-560.

Stewart, I.T. 2009. Changes in Snowpack and Snowmelt Runoff for Key Mountain Regions. Hydrological Processes 23:78-94. DOI: 10.1002/hyp.7128

Stillwater Sciences. 2012. Analysis of Long-term River Regulation Effects on Genetic Connectivity of Foothill Yellow-legged Frogs (*Rana boylii*) in the Alameda Creek Watershed. Final Report. Prepared by Stillwater Sciences, Berkeley, CA for SFPUC, San Francisco, CA.

Stopper, G.F., L. Hecker, R.A. Franssen, and S.K. Sessions. 2002. How Trematodes Cause Limb Deformities in Amphibians. Journal of Experimental Zoology Part B (Molecular and Developmental Evolution) 294:252-263.

Storer, T.I. 1923. Coastal Range of Yellow-legged Frog in California. Copeia 114:8.

Storer, T.I. 1925. A Synopsis of the Amphibia of California. University of California Publication Zoology 27:1-342.

Sweet, S.S. 1983. Mechanics of a Natural Extinction Event: *Rana boylii* in Southern California. Abstract of paper presented at the Joint Annual Meeting of the Herpetologists' League and Society for the Study of Amphibians and Reptiles 7-12 August 1983, Salt Lake City, UT.

Syphard, A.D., V.C. Radeloff, T.J. Hawbaker, and S.I. Stewart. 2009. Conservation Threats Due to Human-Caused Increases in Fire Frequency in Mediterranean-Climate Ecosystems. Conservation Biology 23(3):758–769. DOI: 10.1111/j.1523-1739.2009.01223.x

Syphard, A.D., V.C. Radeloff, J.E. Keeley, T.J. Hawbaker, M.K. Clayton, S.I. Stewart, and R.B. Hammer. 2007. Human Influence on California Fire Regimes. Ecological Applications 17(5):1388-1402.

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573.

Thompson, C., R. Sweitzer, M. Gabriel, K. Purcell, R. Barrett, and R. Poppenga. 2014. Impacts of Rodenticide and Insecticide Toxicants from Marijuana Cultivation Sites on Fisher Survival Rates in the Sierra National Forest, California. Conservation Letters 7(2):91-102.

Thomson, R.C., A.N. Wright, and H.B. Shaffer. 2016. California Amphibian and Reptile Species of Special Concern. University of California Press, Berkeley, CA.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

Tracey, J.A., C.J. Rochester, S.A. Hathaway, K.L. Preston, A.D. Syphard, A.G. Vandergast, J.E. Diffendorfer, J. Franklin, J.B. MacKenzie, T.A. Oberbauer, S. Tremor, C.S. Winchell, and R.N. Fisher. 2018. Prioritizing Conserved Areas Threatened by Wildfire and Fragmentation for Monitoring and Management. PLoS ONE 13(9):e0200203. https://doi.org/10.1371/journal.pone.0200203

Troïanowski, M., N. Mondy, A. Dumet, C. Arcajo, and T. Lengagne. 2017. Effects of Traffic Noise on Tree Frog Stress Levels, Immunity, and Color Signaling. Conservation Biology 31(5):1132-1140.

Twitty, V.C., D. Grant, and O. Anderson. 1967. Amphibian Orientation: An Unexpected Observation. Science 155(3760):352-353.

Unrine, J.M., C.H. Jagoe, W.A. Hopkins, and H.A. Brant. 2004. Adverse Effects of Ecologically Relevant Dietary Mercury Exposure in Southern Leopard Frog (*Rana sphenocephala*) Larvae. Environmental Toxicology and Chemistry 23(12):2964-2970.

U.S. Fish and Wildlife Service [USFWS]. 1998. Recovery Plan for the Shasta Crayfish (*Pacifastacus fortis*). U.S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service [USFWS]. 2015. Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions. Federal Register 80(126):37568-37579.

U.S. Fish and Wildlife Service [USFWS] and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report. U.S. Fish and Wildlife Service, Arcata, CA.

U.S. Forest Service [USFS]. 2004. Sierra Nevada Forest Plan Amendment. Final Supplemental Environmental Impact Statement, Record of Decision.

U.S. Forest Service [USFS] and Bureau of Land Management [BLM]. 1994. Standards and guidelines for management of habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl.

Van Wagner, T.J. 1996. Selected Life-History and Ecological Aspects of a Population of Foothill Yellow-legged Frogs (*Rana boylii*) from Clear Creek, Nevada County, California. Master's Thesis. California State University Chico, Chico, CA.

Volpe, R.J., III, R. Green, D. Heien, and R. Howitt. 2010. Wine-Grape Production Trends Reflect Evolving Consumer Demand over 30 Years. California Agriculture 64(1):42-46.

Wang, I.J., J.C. Brenner, and V. Bustic. 2017. Cannabis, an Emerging Agricultural Crop, Leads to Deforestation and Fragmentation. Frontiers in Ecology and the Environment 15(9):495-501. DOI: 10.1002/fee.1634

Warren, D.L., A.N. Wright, S.N. Seifert, and H.B. Shaffer. 2014. Incorporating Model Complexity and Spatial Sampling Bias into Ecological Niche Models of Climate Change Risks Faced by 90 California Vertebrate Species of Concern. Diversity and Distributions 20:334-343. DOI: 10.1111/ddi.12160

Welsh, H.H., Jr., and G.R. Hodgson. 2011. Spatial Relationships in a Dendritic Network: The Herpetofaunal Metacommunity of the Mattole River Catchment of Northwest California. Ecography 34:49-66. DOI: 10.1111/j.1600-0587.2010.06123.x

Welsh, H.H., Jr., G.R. Hodgson, and A.J. Lind. 2005. Ecography of the Herpetofauna of a Northern California Watershed: Linking Species Patterson to Landscape Processes. Ecography 23:521-536.

Welsh, H.H., Jr., and L.M. Ollivier. 1998. Stream Amphibians as Indicators of Ecosystem Stress: A Case Study from California's Redwoods. Ecological Applications 8(4):1118-1132.

Werschkul, D.F., and M.T. Christensen. 1977. Differential Predation by *Lepomis macrochirus* on the Eggs and Tadpoles of *Rana*. Herpetologica 33(2):237-241.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Science 313(5789):940-943. DOI: 10.1126/science.1128834

Wheeler, C.A., J.B. Bettaso, D.T. Ashton and H.H. Welsh, Jr. 2014. Effects of Water Temperature on Breeding Phenology, Growth, and Metamorphosis of Foothill Yellow-legged Frogs (*Rana boylii*): A Case Study of the Regulated Mainstem and Unregulated Tributaries of California's Trinity River. River Research and Applications 31:1276-1286. DOI: 10.1002/rra.2820

Wheeler, C.A., J.M. Garwood, and H.H. Welsh, Jr. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Physiological Skin Color Transformation. Herpetological Review 36(2):164-165.

Wheeler, C.A., A.J. Lind, H.H. Welsh, Jr., and A.K. Cummings. 2018. Factors that Influence the Timing of Calling and Oviposition of a Lotic Frog in Northwestern California. Journal of Herpetology 52(3):289-298.

Wheeler, C.A., and H.H. Welsh, Jr. 2008. Mating Strategy and Breeding Patterns of the Foothill Yellow-legged Frog (*Rana boylii*). Herpetological Conservation and Biology 3(2):128-142.

Wheeler, C.A., H.H. Welsh, Jr., and T. Roelofs. 2006. Oviposition Site Selection, Movement, and Spatial Ecology of the Foothill Yellow-legged Frog (*Rana boylii*). Final Report to the California Department of Fish and Game Contract No. P0385106, Sacramento, CA.

Williams, A.P., R. Seager, J.T. Abatzoglou, B.I. Cook, J.E. Smerdon, and E.R. Cook. 2015. Contribution of Anthropogenic Warming to California Drought During 2012–2014. Geophysical Research Letters 42:6819-6828. DOI: 10.1002/2015GL064924

Williams S.E., L.P. Shoo, J.L. Isaac, A.A. Hoffmann, and G. Langham. 2008. Towards an Integrated Framework for Assessing the Vulnerability of Species to Climate Change. PLoS Biol 6(12):e325. DOI: 10.1371/journal.pbio.0060325

Wiseman, K.D., and J. Bettaso. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Cannibalism and Predation. Herpetological Review 38(2):193.

Wiseman, K.D., K.R. Marlow, R.E. Jackman, and J.E. Drennan. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(2):162-163.

Wright, A.N., R.J. Hijmans, M.W. Schwartz, and H.B. Shaffer. 2013. California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change. Final Report to the California Department of Fish and Wildlife. Contract No. P0685904, Sacramento, CA.

Yap, T.A., M.S. Koo, R.F. Ambrose, and V.T. Vredenburg. 2018. Introduced Bullfrog Facilitates Pathogen Invasion in the Western United States. PLoS ONE 13(4):e0188384. https://doi.org/10.1371/journal.pone.0188384

Yarnell, S.M. 2005. Spatial Heterogeneity of *Rana boylii* Habitat: Physical Properties, Quantification and Ecological Meaningfulness. PhD Dissertation. University of California, Davis.

Yarnell, S.M., J.H. Viers, and J.F. Mount. 2010. Ecology and Management of the Spring Snowmelt Recession. Bioscience 60(2):114-127.

Yoon, J-H., S-Y.S. Wang, R.R. Gillies, B. Kravitz, L. Hipps, and P.J. Rasch. 2015. Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle under Global Warming. Nature Communications 6:8657. DOI: 10.1038/ncomms9657

Young, C.A., M. Escobar, M. Fernandes, B. Joyce, M. Kiparsky, J.F. Mount, V. Mehta, J.H. Viers, and D. Yates. 2009. Modeling the Hydrology of California's Sierra Nevada for Sub-Watershed Scale Adaptation to Climate Change. Journal of American Water Resources Association 45:1409-1423.

Zhang, H., C. Cai, W. Fang, J. Wang, Y. Zhang, J. Liu, and X. Jia. 2013. Oxidative Damage and Apoptosis Induced by Microcystin-LR in the Liver of *Rana nigromaculata* in Vivo. Aquatic Toxicology 140-141:11-18.

Zillioux, E.J., D.B. Porcella, and J.M. Benoit. 1993. Mercury Cycling and Effects in Freshwater Wetland Ecosystems. Environmental Toxicology and Chemistry 12:2245-2264.

Zweifel, R.G. 1955. Ecology, Distribution, and Systematics of Frogs of the *Rana boylei* Group. University of California Publications in Zoology 54(4):207-292.

Zweifel, R.G. 1968. *Rana boylii* Baird, Foothill Yellow-legged Frog. Catalogue of American Amphibians and Reptiles. Pp. 71.1-71.2.

Personal Communications

Alvarez, J. 2017. The Wildlife Project. Email to the Department.

Alvarez, J. 2018. The Wildlife Project. Letter to Tom Eakin, Peter Michael Winery, provided to the Department.

Anderson, D.G. 2017. Redwood National Park. Foothill Yellow-legged Frog (*Rana boylii*) Survey of Redwood Creek on August 28, 2017, Mainstem Redwood Creek, Redwood National Park, Humboldt County, California.

Ashton, D. 2017. U.S. Geological Survey. Email response to Department solicitation for information.

Blanchard, K. 2018. California Department of Fish and Wildlife. Email response to Department solicitation for information.

Bourque, R. 2018. California Department of Fish and Wildlife. Email.

Bourque, R. 2019. California Department of Fish and Wildlife. Internal review comments.

Chinnichi, S. 2017. Humboldt Redwood Company. Email response to the Department solicitation for information.

Grefsrud, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Hamm, K. 2017. Green Diamond Resource Company. Email response to the Department solicitation for information.

Kundargi, K., 2014. California Department of Fish and Wildlife. Internal memo.

Kupferberg, S. 2018. UC Berkeley. Spreadsheet of Eel River egg mass survey results.

Kupferberg, S. 2019. UC Berkeley. Spreadsheet of breeding censuses and clutch density plots by river.

Kupferberg, S., and A. Lind. 2017. UC Berkeley and U.S. Forest Service. Draft recommendation for best management practices to the Department's North Central Region.

Kupferberg, S., and R. Peek. 2018. UC Davis and UC Berkeley. Email to the Department.

Kupferberg, S., R. Peek, and A. Catenazzi. 2015. UC Berkeley, UC Davis, and Southern Illinois University Carbondale. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., and M. Power. 2015. UC Berkeley. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., M. van Hattem, and W. Stokes. 2017. UC Berkeley and California Department of Fish and Wildlife. Email about lower flows in the South Fork Eel River and upstream cannabis.

Rose, T. 2014. Wildlife Photographer. Photographs of river otters consuming Foothill Yellow-legged Frogs on the Eel River.

Smith, J. 2015. San Jose State University. Frog and Turtle Studies on Upper Coyote Creek for (2010-2015; cumulative report).

Smith, J. 2016. San Jose State University. Upper Coyote Creek Stream Survey Report – 20 April 2016.

Smith, J. 2017. San Jose State University. Upper Llagas Creek Fish Resources in Response to the Recent Drought, Fire, and Extreme Wet Winter, 8 October 2017.

Sweet, S. 2017. University of California Santa Barbara. Email to the Department.

van Hattem, M. 2018. California Department of Fish and Wildlife. Telephone call.

van Hattem, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Weiss, K. 2018. California Department of Fish and Wildlife. Email.

Geographic Information System Data Sources

Amphibian and Reptile Species of Special Concern [ARSSC]. 2012. Museum Dataset.

Biological Information Observation System [BIOS]. Aquatic Organisms [ds193]; Aquatic Ecotoxicology - Whiskeytown NRA 2002-2003 [ds199]; North American Herpetological Education and Research Project (HERP) - Gov [ds1127]; and Electric Power Plants - California Energy Commission [ds2650].

California Department of Fish and Wildlife [CDFW]. Various Unpublished Foothill Yellow-legged Frog Observations from 2009 through 2018.

California Department of Food and Agriculture [CDFA]. Temporary Licenses Issued for Commercial Cannabis Cultivation, January 2019 version.

California Department of Forestry [CAL FIRE]. 2017 Fire Perimeters and 2018 Supplement.

California Department of Water Resources [DWR]. 2000. Dams under the Jurisdiction of the Division of Safety and Dams.

California Military Department [CMD]. Camp Roberts Boundary.

California Natural Diversity Database [CNDDB]. February 2019 version.

California Protected Areas Database [CPAD]. Public Lands, 2017 version.

California Wildlife Habitat Relationships [CWHR]. 2014 Range Map Modified to Include the Sutter Buttes.

Electronic Water Rights Information Management System [eWRIMS]. Points of Diversion - State Water Resources Control Board, 2019 version.

Facility Registry Service [FRS]. Power Plants Operated by the Army Corps of Engineers – U.S. Environmental Protection Agency Facility Registry Service, 2014 version.

Humboldt Redwood Company [HRC]. Incidental Foothill Yellow-legged Frog Observations from 1995 to 2018.

Mendocino Redwoods Company [MRC]. Foothill Yellow-legged Frog Egg Mass Survey Results from 2017 and 2018.

National Hydrography Dataset [NHD]. Watershed Boundary Dataset, 2018 version.

PRISM Climate Group [PRISM]. Annual Average Precipitation for 2012 through 2016; and the 30 Year Average from 1980-2010.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

U.S. Bureau of Land Management [BLM]. Tribal Lands - Bureau of Indian Affairs Surface Management, 2014 version.

U.S. Department of Defense [DOD]. Military Lands Boundaries in California.

Patterson, Laura@Wildlife

From: Jim Mcguire <mcguirej@berkeley.edu>
Sent: Monday, June 24, 2019 1:08 PM
To: Patterson, Laura@Wildlife
Subject: Re: Peer Review Request: Foothill Yellow-legged Frog Status Review
Attachments: DRAFT FYLF Status Review-2019.05.21.docx; Untitled attachment 00038.html

Hi Laura,

I've attached the Draft report with my comments incorporated directly in the document via Track Changes. I'm extremely impressed by the depth and detail provided in your report! Although I didn't have much in the way of suggested changes to the document, I gave it a careful read and learned a lot myself. I noted a few typos and and suggested a few updates to the ranid taxonomy section, but you and the various folks that were cited extensively in the report (especially Sarah Kupferberg and Amy Lind) obviously know a ton about these animals (far more than I do)..

I agree whole-heartedly with your assessment of the listing needs for the genetic clades. My question for you now - having never reviewed one of these reports and being naive to the process - is what sort of review you need from me. Will my review simply be used by you to improve your document, or do you need formal reviews that accompany the final document and thus need to be detailed assessments? In other words, am I simply helping you fine-tune your document or is this more like an NSF grant proposal and the review will influence whomever will be evaluating your recommendations? Just let me know!

Cheers,

Jim

STATE OF CALIFORNIA
NATURAL RESOURCES AGENCY
DEPARTMENT OF FISH AND WILDLIFE

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF THE **FOOTHILL YELLOW-LEGGED FROG** (*Rana boylii*) IN CALIFORNIA

CHARLTON H. BONHAM, DIRECTOR
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
External Peer Review Draft

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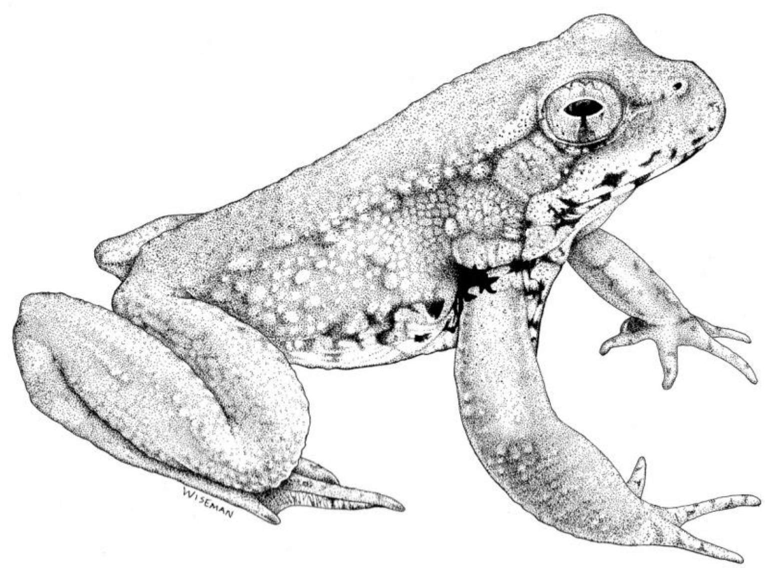

ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

[To be completed after external peer review]

REGULATORY SETTING

Petition Evaluation Process

A petition to list the Foothill Yellow-legged Frog (*Rana boylii*) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on December 14, 2016 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on December 22, 2016 and published a formal notice of receipt of the petition on January 20, 2017 (Cal. Reg. Notice Register 2017, No. 3-Z, p. 46). A petition to list or delist a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3).

On April 17, 2017, the Department provided the Commission with its evaluation of the petition, "Evaluation of the Petition from the Center For Biological Diversity to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on June 21, 2017, in Smith River, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Foothill Yellow-legged Frog was designated a candidate species on July 7, 2017 (Cal. Reg. Notice Register 2017, No. 27-Z, p. 986).

Status Review Overview

The Commission's action designating the Foothill Yellow-legged Frog as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 21, 2018, in Sacramento, California, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

This status review report is not intended to be an exhaustive review of all published scientific literature relevant to the Foothill Yellow-legged Frog; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to the Foothill Yellow-legged Frog. This review is intended to provide the Commission with the most current information on the Foothill Yellow-legged Frog and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The status review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

Federal Endangered Species Act Review

The Foothill Yellow-legged Frog is currently under review for possible listing as threatened or endangered under the federal Endangered Species Act (ESA) in response to a July 11, 2012 petition submitted by the Center for Biological Diversity. On July 1, 2015, the U.S. Fish and Wildlife Service (USFWS) published its 90-day finding that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted and initiated a status review of the species (USFWS 2015). On March 16, 2016, the Center for Biological Diversity sued the USFWS to compel issuance of a 12-month finding on whether listing under the ESA is warranted. On August 30, 2016, the parties reached a stipulated settlement agreement that the USFWS shall publish its 12-month finding in the Federal Register on or before September 30, 2020 (*Center for Biological Diversity v. S.M.R. Jewell* (D.D.C. Aug. 30, 2016, No. 16-CV-00503)).

BIOLOGY AND ECOLOGY

Species Description and Life History

> *"In its life-history* boylii *exhibits several striking specializations which are in all probability related to the requirements of life of a stream-dwelling species"* – Tracy I. Storer, 1925

The Foothill Yellow-legged Frog is a small- to medium-sized frog; adults range from 38 to 81 mm (1.5-3.2 in) snout to urostyle length (SUL) with females attaining a larger size than males and males possessing paired internal vocal sacs (Zweifel 1955, Nussbaum et al. 1983, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs are typically gray, brown, olive, or reddish with brown-black flecking and mottling, which generally matches the substrate of the stream in which they reside (Nussbaum et al. 1983, Stebbins and McGinnis 2012). They often have a pale triangle between the eyes and snout and broad dark bars on the hind legs (Zweifel 1955, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs have a relatively squat body and granular skin, giving them a rough appearance similar to a toad, and fully webbed feet with slightly expanded toe tips (Nussbaum et al. 1983). The tympanum is also rough

and relatively small compared to congeners at around one-half the diameter of the eye (Zweifel 1955). The dorsolateral folds (glandular ridges extending from the eye area to the rump) in Foothill Yellow-legged Frogs are indistinct compared to other western North American ranids (Stebbins and McGinnis 2012). Ventrally, the abdomen is white with variable amounts of dark mottling on the chest and throat, which are unique enough to be used to identify individuals (Marlow et al. 2016). As their name suggests, the underside of their hind limbs and lower abdomen are often yellow; however, individuals with orange and red have been observed within the range of the California Red-legged Frog (*Rana draytonii*), making hindlimb coloration a poor diagnostic characteristic for this species (Jennings and Hayes 2005).

Adult females likely lay one clutch of eggs per year and may breed every year (Storer 1925, Wheeler et al. 2006). Foothill Yellow-legged Frog egg masses resemble a compact cluster of grapes approximately 45 to 90 mm (1.8-3.5 in) in diameter length-wise and contain anywhere from around 100 to over 3,000 eggs (Kupferberg et al. 2009c, Hayes et al. 2016). The individual embryos are dark brown to black with a lighter area at the vegetative pole and surrounded by three jelly envelopes that range in diameter from approximately 3.9 to 6.0 mm (0.15-0.25 in) (Storer 1925, Zweifel 1955, Hayes et al. 2016).

Foothill Yellow-legged Frog tadpoles hatch out around 7.5 mm (0.3 in) long and are a dark brown or black (Storer 1925, Zweifel 1955). They grow rapidly to 37 to 56 mm (1.5-2.2 in) and turn olive with a coarse brown mottling above and an opaque silvery color below (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012). Their eyes are positioned dorsally when viewed from above (i.e., within the outline of the head), and their mouths are large, downward-oriented, and suction-like with several tooth rows (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012, Hayes et al. 2016). Foothill Yellow-legged Frogs metamorphose at around 14-17 mm (0.55-0.67 in) SUL (Fellers 2005). Sexual maturity is attained at around 30-40 mm (1.2-1.6 in) SUL and 1 year for males and around 40-50 mm (1.6-2.0 in) SUL and 3 years for females, although in some populations this has been accelerated by a year (Zweifel 1955, Kupferberg et al. 2009c, Breedveld and Ellis 2018). During the breeding season, males can be distinguished from females by the presence of nuptial pads (swollen darkened thumb bases that aid in holding females during amplexus) and calling, which frequently occurs underwater but sometimes from the surface (MacTague and Northen 1993, Stebbins 2003, Silver 2017).

The reported lifespan of Foothill Yellow-legged Frogs varies widely by study. Storer (1925) and Van Wagner (1996) estimated a maximum age of 2 years for both sexes and the vast majority of the population. Breedveld and Ellis (2018) calculated the typical lifespan of males at 3-4 years and 5-6 years for females. Bourque (2008), using skeletochronology, found an individual over 7 years old and a mean age of 4.7 and 3.6 years for males and females, respectively. Drennan et al. (2015) estimated maximum age at 13 years for both sexes in a Sierra Nevada population and 12 for males and 11 for females in a Coast Range population.

Range and Distribution

Foothill Yellow-legged Frogs historically ranged from the Willamette River drainage in Oregon west of the Sierra-Cascade crest to at least the San Gabriel River drainage in Los Angeles County, California (Figure 1; Zweifel 1955, Stebbins 2003). In addition, a disjunct population was reported from 2,040 m

Figure 1. Foothill Yellow-legged Frog historical range (adapted from CWHR, Loomis [1965], Nussbaum et al. [1983])

(6,700 ft) in the Sierra San Pedro Mártir, Baja California Norte, México (Loomis 1965). In California, the species occupies foothill and mountain streams in the Klamath, Cascade, Sutter Buttes, Coast, Sierra Nevada, and Transverse ranges from sea level to 1,940 m (6,400 ft), but generally below 1,525 m (5,000 ft) (Hemphill 1952, Nussbaum et al. 1983, Stebbins 2003, Olson et al. 2016). Zweifel (1955) considered Foothill Yellow-legged Frogs to be present and abundant throughout their range where streams possessed suitable habitat.

Taxonomy and Phylogeny

Foothill Yellow-legged Frogs belong to the family Ranidae (true frogs), which inhabits every continent except Antarctica and contains more than 700 species (Stebbins 2003). The species was first described by Baird (1854) as *Rana boylii*. After substantial taxonomic uncertainty with respect to its relationship to other ranids (frogs in the family Ranidae) and several name changes over the next century, the Foothill Yellow-legged Frog (*R. boylii* with no subspecific epithet) was ~~eventually~~ again recognized as a ~~distinct~~ monotypic species ~~again~~ by Zweifel (1955, 1968). The phylogenetic relationships among the western North American *Rana* spp. have been revised several times and are still not entirely resolved (Thomson et al. 2016). The Foothill Yellow-legged Frog was previously thought to be most closely related to the higher elevation Mountain Yellow-legged Frog (*R. muscosa*) (Zweifel 1955; Green 1986a,b). However, genetic analyses undertaken by Macey et al. (2001) and Hillis and Wilcox (2005) suggest they are more closely related to Oregon Spotted Frogs (*R. pretiosa*) and Columbia Spotted Frogs (*R. luteiventris*), respectively.

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Population Structure and Genetic Diversity

Foothill Yellow-legged Frog populations exhibit varying levels of partitioning and genetic diversity at different spatial scales. At the coarse landscape level across the species' extant range, McCartney-Melstad et al. (2018) genomic data set composed of RadSeq data, analysis of which recovered five deeply divergent, geographically cohesive, genetic clades (Figure 2), while Peek (2018) (using ???? data) recovered six (Figure 3). Genetic divergence ~~is~~ occurs during the process of speciation; it is a measure of the number of mutations accumulated by populations over time from a shared ancestor that differentiate them from the other populations in a species. When genetic divergence among clades is large enough, it can be used as a tool to assist in the ~~define~~ identification of new species or subspecies.

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The geographic breaks among the five clades were similar between the studies, but Peek (2018) identified a separate deeply divergent genetic clade in the Feather River watershed that is distinct from the rest of the northern Sierra Nevada clade. The five clades the two studies shared include the following [Note: naming conventions follow McCartney-Melstad et al. (2018) and Peek (2018)]:

(1) Northwest/North Coast: north of San Francisco Bay in the Coast Ranges and east into Tehama County;
(2) Northeast/Northern Sierra: northern El Dorado County (North Fork American River watershed, includes Middle Fork) and north in the Sierra Nevada to southern Plumas County (Upper Yuba River watershed);

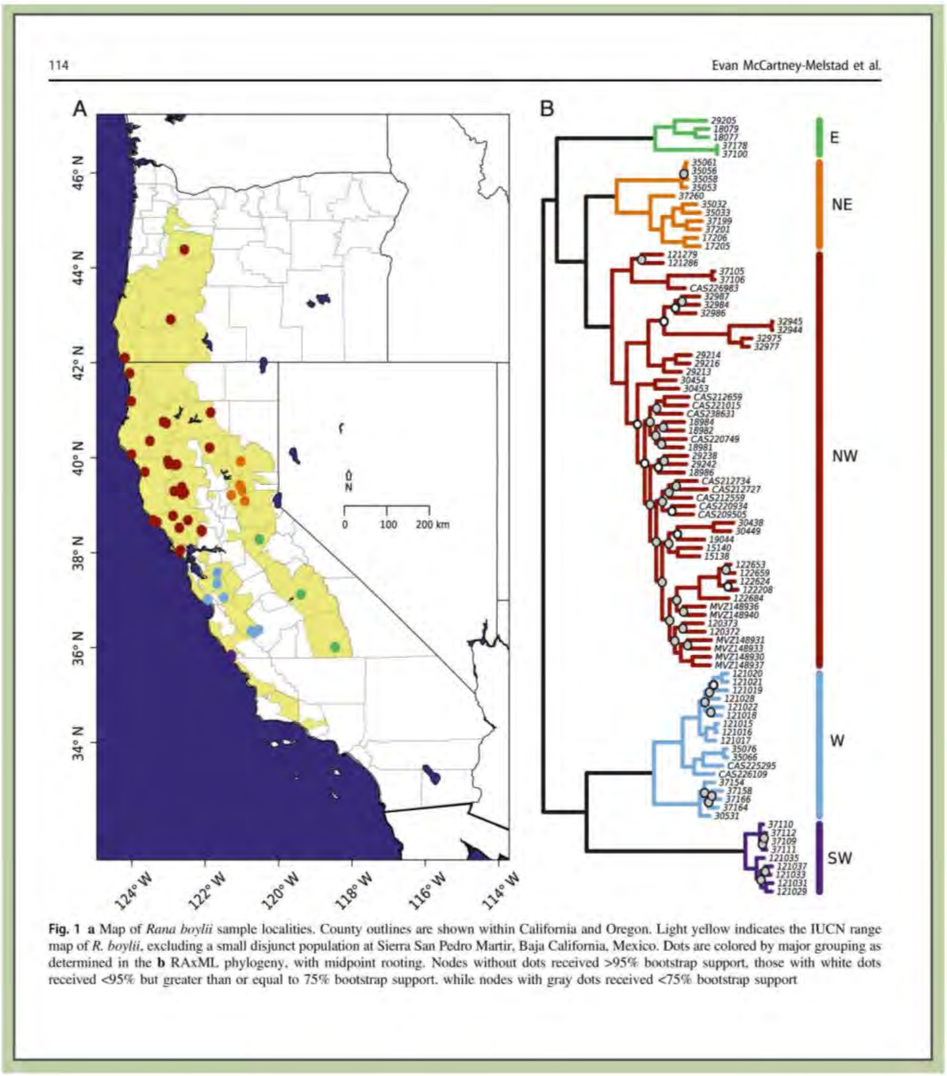

Fig. 1 **a** Map of *Rana boylii* sample localities. County outlines are shown within California and Oregon. Light yellow indicates the IUCN range map of *R. boylii*, excluding a small disjunct population at Sierra San Pedro Martir, Baja California, Mexico. Dots are colored by major grouping as determined in the **b** RAxML phylogeny, with midpoint rooting. Nodes without dots received >95% bootstrap support, those with white dots received <95% but greater than or equal to 75% bootstrap support, while nodes with gray dots received <75% bootstrap support

Figure 2. Foothill Yellow-legged Frog clades by McCartney-Melstad et al. (2018)

(3) East/Southern Sierra: El Dorado County (South Fork American River watershed) and south in the Sierra Nevada [no samples from Amador County were tested, but they would most likely fall within this clade because it is located between two other populations that occur within this clade];

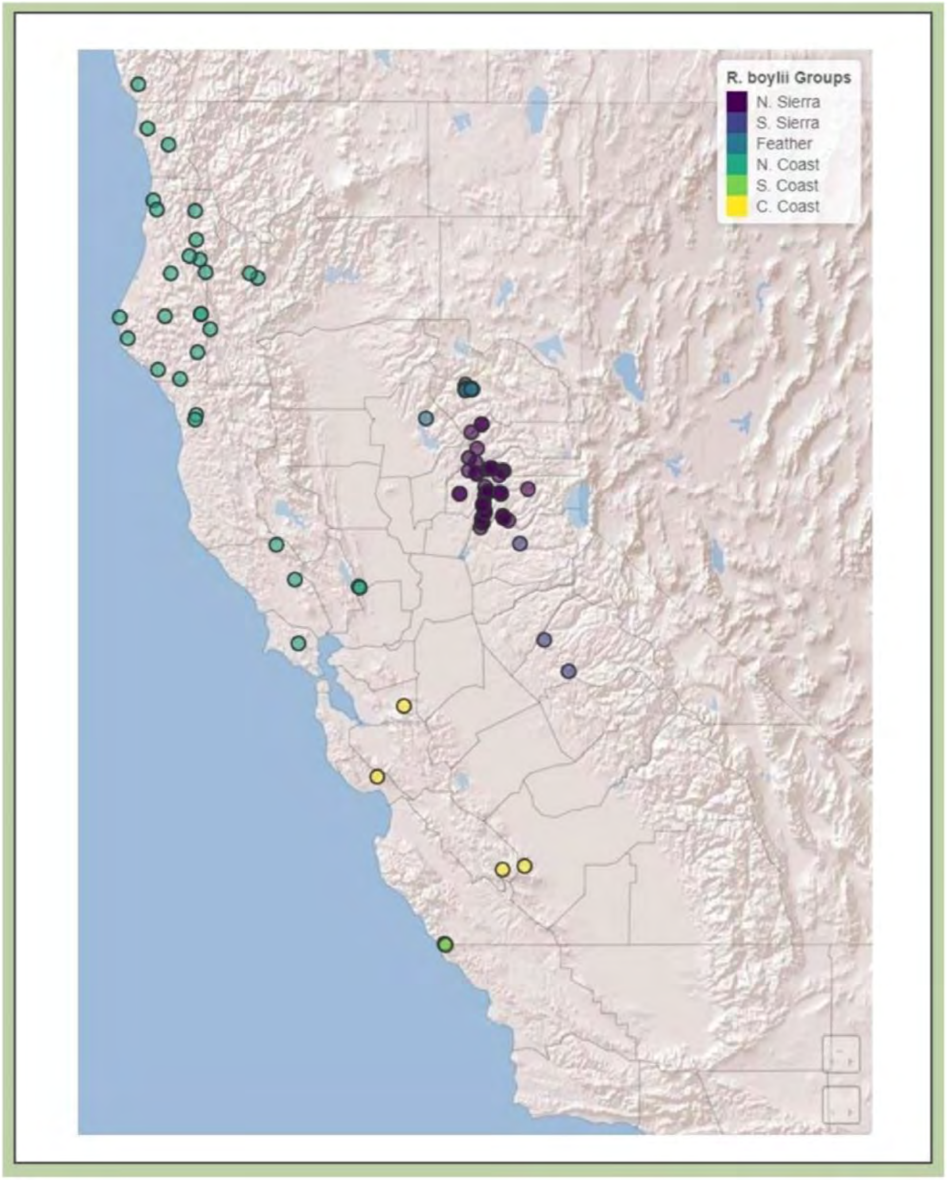

Figure 3. Foothill Yellow-legged Frog clades by Peek (2018)

(4) West/Central Coast: south of San Francisco Bay in the Coast Ranges to San Benito and Monterey counties, presumably east of the San Andreas Fault/Salinas Valley;
(5) Southwest/South Coast presumably west of the San Andreas Fault/Salinas Valley in Monterey County and south in the Coast Ranges.

The Feather River clade is found primarily in Plumas and Butte counties (Peek 2018). Peek's analysis found that this clade is as distinct as the rest of the Sierra Nevada as a cohesive group and all the coastal populations as one group, meaning it was found to be deeply divergent from the rest of the clades. McCartney-Melstad et al. (2018) also recognized the Feather River watershed as distinct from the rest of the northern Sierra but not as deeply divergent from the other clades as Peek. The Feather River watershed is also the only known location where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs (*R. sierrae*) co-occur and where two F1 hybrids (50% ancestry from each species) were found (Peek 2018). In addition, Peek's modeling results only weakly supported dividing the West/Central Coast and Southwest/South Coast groups into separate clades.

Previous work conducted by Lind et al. (2011) based on two mitochondrial genes found a somewhat similar pattern, that populations on the periphery of the species' range are considerably genetically divergent from the rest of the range. Their results suggested that hydrologic regions and river basins were important landscape features that influenced the genetic structure of Foothill Yellow-legged Frog populations. However, using more modern genomic techniques, McCartney-Melstad et al. (2018) found nearly twice the variation among the five phylogenetic clades than among drainage basins, indicating other factors contributed to current population structure. They report that the depth of genetic divergence among Foothill Yellow-legged Frog clades exceeds that of any anuran (frog or toad) for which similar data are available and recommend using them as management units instead of the previously suggested watershed boundaries.

Levels of genetic diversity within the clades differed significantly. Genetic diversity gives species the ability to adapt to changing conditions (i.e., evolve), and its loss often signals extreme population and range reductions as well as potential inbreeding depression that can reduce survival and reproductive success (Lande and Shannon 1996, Hoffmann and Sgrò 2011, McCartney-Melstad et al. 2018). Loss of genetic diversity in Foothill Yellow-legged Frogs largely follows a north-to-south pattern with the southern clades (Southwest/South Coast and East/Southern Sierra) possessing the least amount (McCartney-Melstad et al. 2018, Peek 2018). In addition, these study results demonstrate that Foothill Yellow-legged Frogs have lost genetic diversity over time across their entire range except for the large Northwest/North Coast clade, which appears to have undergone a relatively recent population expansion (McCartney-Melstad et al. 2018, Peek 2018).

At a watershed scale, Dever (2007) found that tributaries to rivers and streams are important for preserving genetic diversity, and populations separated by more than 10 km (6.2 mi) show signs of genetic isolation. In other words, even in the absence of anthropogenic barriers to dispersal (e.g., dams and reservoirs), individuals located more than 10 km (6.2 mi) are not typically considered part of a single interbreeding population (Olson and Davis 2009). Peek (2011, 2018) reported that at this finer-scale, population structure and genetic diversity appear to be more strongly influenced by river regulation type (i.e., dammed or undammed) than to geographic distance or watershed boundaries. In general, regulated (dammed) rivers had limited gene flow and higher genetic divergence among subpopulations compared with unregulated (undammed) rivers (Peek 2011, 2018). In addition, differences in water flow regimes within regulated rivers affected connectivity (Peek 2011, 2018). Subpopulations in hydropeaking reaches, in which pulsed flows are used for electricity generation or whitewater boating, exhibited significantly lower gene flow than those in bypass reaches where water is diverted from upstream in the basin down to power generating facilities (Figure 4; Peek 2018). River regulation had a greater influence on genetic differentiation among sites than geographic distance in the Alameda Creek watershed as well (Stillwater Sciences 2012). Reduced connectivity among sites leads to lower gene flow and a loss of genetic diversity through genetic drift, which can diminish adaptability to changing environmental conditions (Palstra and Ruzzante 2008). Peek (2011) posits that given the *R. boylii* species group is estimated to be 8 million years old (Macey et al. 2001), the significant reductions in connectivity and genetic diversity over short evolutionary time periods in regulated rivers (often less than 50 years from the time of dam construction) is cause for concern, particularly when combined with small population sizes.

Habitat Associations and Use

> *"These frogs are so closely restricted to streams that it is unusual to find one at a greater distance from the water than it could cover in one or two leaps."* – Richard G. Zweifel, 1955

Foothill Yellow-legged Frogs inhabit rivers and streams ranging from primarily rain-fed (coastal populations) to primarily snow-influenced (most Sierra Nevada and Klamath-Cascade populations) from headwater streams to large rivers (Bury and Sisk 1997, Wheeler et al. 2014). Occupied rivers and streams flow through a variety of vegetation types including hardwood, conifer, and valley-foothill riparian forests; mixed chaparral; and wet meadows (Hayes et al. 2016). Because the species is so widespread and can be found in so many types of habitats, the vegetation community is likely less important in determining Foothill Yellow-legged Frog occupancy and abundance than the aquatic biotic and abiotic conditions in the specific river, stream, or reach (Zweifel 1955). The species is an obligate stream-breeder, which sets it apart from other western North American ranids (Wheeler et al. 2014). Foothill Yellow-legged Frog habitat is generally characterized as partly-shaded, shallow, perennial rivers and streams with a low gradient and rocky substrate that is at least cobble-sized (Zweifel 1955, Hayes and Jennings 1988). However, the use of intermittent and ephemeral streams by post-metamorphic Foothill Yellow-legged Frogs may not be all that uncommon in some parts of the species' range in California (R. Bourque pers. comm. 2019). The species has been reported from some atypical habitats as well, including ponds, isolated pools in intermittent streams, and meadows along the edge of streams that lack a rocky substrate (Fitch 1938, Zweifel 1955, J. Alvarez pers. comm. 2017, CDFW 2018a).

As stream-breeding poikilotherms (animals whose internal temperature varies with ambient temperature), appropriate flow velocity, temperature, and water availability are critically important to Foothill Yellow-legged Frogs (Kupferberg 1996a, Van Wagner 1996, Wheeler et al. 2006, Lind et al. 2016). Habitat quality is also influenced by hydrologic regime (regulated vs. unregulated), substrate, presence of non-native predators and competitors, water depth, and availability of high-quality food and basking sites (Lind et al. 1996, Yarnell 2005, Wheeler et al. 2006, Catenazzi and Kupferberg 2017). Habitat suitability and use vary by life stage, sex, geographic location, watershed size, and season and

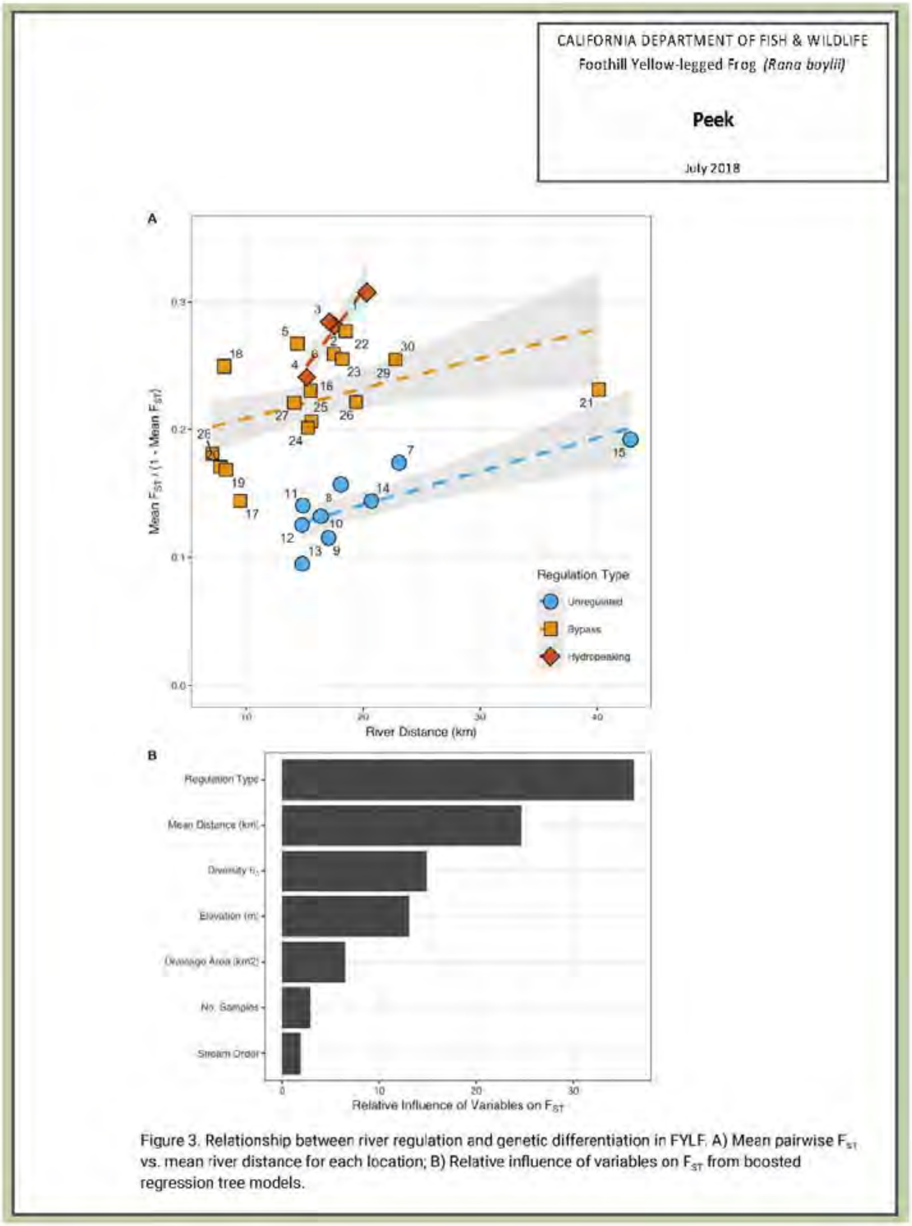

Figure 4. River regulation's relative influence on genetic differentiation from Peek (2018)

can generally be categorized as breeding and rearing habitat, nonbreeding active season habitat, and overwintering habitat (Van Wagner 1996, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011, Hayes et al. 2016, Catenazzi and Kupferberg 2017). Yarnell (2005) located higher densities of Foothill Yellow-legged Frogs in areas with greater habitat heterogeneity and suggested that they were selecting ~~for~~ sites that possessed the diversity of habitats necessary to support each life stage within a relatively short distance.

Breeding and Rearing Habitat

Suitable breeding habitat must be connected to suitable rearing habitat for metamorphosis to be successful. When this connectivity exists, as flows decline through the season, tadpoles can follow the receding shoreline into areas of high productivity and lower predation risk as opposed to becoming trapped in isolated pools with a high risk of overheating, desiccation, and predation (Kupferberg et al. 2009c).

Several studies on Foothill Yellow-legged Frog breeding habitat, carried out across the species' range in California, reported similar findings. Foothill Yellow-legged Frogs select oviposition (egg-laying) sites within a narrow range of depths, velocities, and substrates and exhibit fidelity to breeding sites that consistently possess suitable microhabitat characteristics over time (Kupferberg 1996a, Bondi et al. 2013, Lind et al. 2016). At a coarse-spatial scale, breeding sites in rivers and large streams are often located near the confluence of tributary streams in sunny, wide, shallow reaches (Kupferberg 1996a, Yarnell 2005, GANDA 2008, Peek 2011). These areas are highly productive compared to cooler, deeper, closed-canopy sites (Catenazzi and Kupferberg 2013). At a fine-spatial scale, females prefer to lay eggs in low velocity areas dominated by cobble- and boulder-sized substrates, often associated with sparsely-vegetated point bars (Kupferberg 1996a, Lind et al. 1996, Van Wagner 1996, Bondi et al. 2013, Lind et al. 2016). They tend to select areas with less variable, more stable flows, and in areas with higher flows at the time of oviposition, they place their eggs on the downstream side of large cobblestones and boulders, which protects them from being washed away (Kupferberg 1996a, Wheeler et al. 2006).

Appropriate rearing temperatures are vital for successful metamorphosis. Tadpoles grow faster and larger in warmer water to a point (Zweifel 1955; Catenazzi and Kupferberg 2017, 2018). Zweifel (1955) conducted experiments on embryonic thermal tolerance and determined that the critical low was approximate 6°C (43°F), and the critical high was around 26°C (79°F). Welsh and Hodgson (2011) determined that best the single variable for predicting Foothill Yellow-legged Frog presence was temperature since none were observed below 13°C (55°F), but numbers increased significantly with increasing temperature. Catenazzi and Kupferberg (2013) measured tadpole thermal preference at 16.5-22.2°C (61.7-72.0°F), and the distribution of Foothill Yellow-legged Frog populations across a watershed was consistent within this temperature range. At temperatures below 16°C (61°F), tadpoles were absent under closed canopy and scarce even with an open canopy (Ibid.). Catenazzi and Kupferberg (2017) found regional differences in apparently suitable breeding temperatures. Inland populations from primarily snowmelt-fed systems with relatively cold water were relegated to reaches that are warmer on average during the warmest 30 days of the year than coastal populations in the chiefly rainfall-fed, and thus warmer, systems (17.6-24.2°C [63.7-75.6°F] vs. 15.7-22.0°C [60.3-71.6°F], respectively).

However, experiments on tadpole thermal preference demonstrated that individuals from different source populations selected similar rearing temperatures, which presumably optimized development (Ibid.). In regulated systems, where water released from dams is often colder than normal, suitable rearing temperatures downstream may be limited (Wheeler et al. 2014, Catenazzi and Kupferberg 2017).

Appropriate flow velocities are also critical for survival to metamorphosis. The velocity at which Foothill Yellow-legged Frog egg masses shear away from the substrate they are adhered to varies according to factors such as depth and degree to which the eggs are sheltered (Spring Rivers Ecological Sciences 2003). This critical velocity is expected to decrease as the egg mass ages due to their reduced structural integrity of the protective jelly envelopes (Hayes et al. 2016). Short-duration increases in flow velocity may be tolerated if the egg masses are somewhat sheltered, but sustained high velocities increase the likelihood of detachment (Kupferberg 1996a, Spring Rivers Ecological Sciences 2003). Hatchlings and tadpoles about to undergo metamorphosis are relatively poor swimmers and require especially slow, stable flows during these stages of development (Kupferberg et al. 2011b). Tadpoles respond to increasing flows by swimming against the current to maintain position for a short period of time and eventually swimming to the bottom and seeking refuge in the rocky substrate's interstitial spaces (Ibid.). When tadpoles are exposed to repeated increases in velocities, their growth and development are delayed (Ibid.). Under experimental conditions, the critical velocity at which tadpoles were swept downstream ranged between 20 and 40 cm/s (0.66-1.31 ft/s); however, as they reach metamorphosis it decreases to as low as 10 cm/s (0.33 ft/s) (Ibid.).

Nonbreeding Active Season Habitat

Post-metamorphic Foothill Yellow-legged Frogs utilize a more diverse range of habitats and are much more dispersed during the nonbreeding active season than the breeding season. Microhabitat preferences appear to vary by location and season, but some patterns are common across the species' range. Foothill Yellow-legged Frogs tend to remain close to the water's edge (average < 3 m [10 ft]); select sunny areas with limited canopy cover; and are often associated with riffles and pools (Zweifel 1955, Hayes and Jennings 1988, Van Wagner 1996, Welsh et al. 2005, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011). Adequate water, food resources, cover from predators, ability to thermoregulate (e.g., presence of basking sites and cool refugia), and absence of non-native predators are important components of nonbreeding active season habitat (Hayes and Jennings 1988, Van Wagner 1996, Catenazzi and Kupferberg 2013).

Overwintering Habitat

Overwintering habitat varies depending on local conditions, but as with the rest of the year, Foothill Yellow-legged Frogs are most often found in or near water where they can forage and take cover from predators and high discharge events (Storer 1925, Zweifel 1955). In larger streams and rivers, Foothill Yellow-legged Frogs are often found along tributaries during the winter where the risk of being displaced by heavy flows is reduced (Kupferberg 1996a, Gonsolin 2010). Bourque (2008) found 36.4% of adult females used intermittent and ephemeral tributaries during the overwintering season. Van

Wagner (1996) located most overwintering frogs using pools with cover such as boulders, root wads, and woody debris. During high flow events, they moved to the stream's edge and took cover under vegetation like sedges (*Carex* sp.) or leaf litter (Ibid.). Rombough (2006) found most Foothill Yellow-legged Frogs under woody debris along the high-water line and often using seeps along the stream-edge, which provided them with moisture, a thermally stable environment, and prey.

Exceptions to the pattern of remaining near the stream's edge during winter have been reported. Cook et al. (2012) observed dozens of juvenile Foothill Yellow-legged Frogs traveling over land, as opposed to using riparian corridors. They were found using upland habitats with an average distance of 71.3 m (234 ft) from water (range: 16-331 m [52-1,086 ft]) (Ibid.). In another example, a single subadult that was found adjacent to a large wetland complex 830 m (2,723 ft) straight-line distance from the wetted edge of the Van Duzen River, although it is possible the wetland was connected to the river via a spillway or drainage that may have served as the movement corridor (CDFW 2018a, R. Bourque pers. comm. 2019).

Seasonal Activity and Movements

Because Foothill Yellow-legged Frogs occupy areas with relatively mild winter temperatures, they can be active year-round, although at low temperatures (< 7°C [44 °F], they become lethargic (Storer 1925, Zweifel 1955, Van Wagner 1996, Bourque 2008). They are active both day and night, and during the day adults are often observed basking on warm objects such as sun-heated rocks, although this is also when their detectability is highest (Fellers 2005, Wheeler et al. 2005). By contrast, Gonsolin (2010) tracked radio-telemetered Foothill Yellow-legged Frogs under substrate a third of the time and underwater a quarter of the time, although nearly all his detections of frogs without transmitters were basking.

Adult Foothill Yellow-legged Frogs migrate from their overwintering sites to breeding habitat in the spring, often from a tributary to its confluence with a larger stream or river. In areas where tributaries dry down, juveniles also make this downstream movement (Haggarty 2006). When the tributary itself is perennial and provides suitable breeding habitat, the frogs may not undertake these long-distance movements (Gonsolin 2010). Cues for adults to initiate this migration to breeding sites are somewhat enigmatic and vary by location, elevation, and amount of precipitation (S. Kupferberg and A. Lind pers. comm. 2017). They can also include day length, water temperature, and sex (GANDA 2008, Gonsolin 2010, Yarnell et al. 2010, Wheeler et al. 2018). Males initiate movements to breeding sites where they congregate in leks (areas of aggregation for courtship displays), and females arrive later and over a longer period (Wheeler and Welsh 2008, Gonsolin 2010). Most males utilize breeding sites associated with their overwintering tributaries, but some move substantial distances to other sites and may use more than one breeding site in the same season (Wheeler and Welsh 2006, GANDA 2008).

While the predictable hydrograph in California consists of wet winters with high flows and dry summers with low flows, the timing and quantity of seasonal discharge can vary significantly from year to year. The timing of oviposition can influence offspring growth and survival. Early breeders risk scouring of egg masses from their substrate by late spring storms in wet years or desiccation if waters recede rapidly, but when they successfully hatch, tadpoles benefit from a longer growing season, which can enable them to metamorphose at a larger size and increase their likelihood of survival (Railsback et al. 2016).

Later breeders are less likely to have their eggs scoured away or desiccated because flows are generally more stable, but they have fewer mate choices, and their tadpoles have a shorter growing period before metamorphosis, reducing their chance of survival (Ibid.). Some evidence indicates larger females, who coincidentally lay larger clutches, breed earlier (Kupferberg et al. 2009c, Gonsolin 2010). Consequently, early season scouring or stranding of egg masses or tadpoles can disproportionately impact the population's reproductive output because later breeders produce fewer and smaller eggs per clutch (Kupferberg et al. 2009c, Gonsolin 2010).

Timing of oviposition is often a function of water temperature and flow, but it consistently occurs on the descending limb of the hydrograph which corresponds to high winter discharge gradually receding toward low summer baseflow (Kupferberg 1996a, GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010, Yarnell et al. 2010). Under natural conditions, the timing coincides with intermittent tributaries drying down and increases in algal blooms that provide forage for tadpoles (Haggarty 2006, Power et al. 2008). At lower elevations, breeding can start in late March or early April, and at mid-elevations, breeding typically occurs in mid-May to mid-June (Gonsolin 2010, S. Kupferberg and A. Lind pers. comm. 2017). The time of year a population initiates breeding can vary by a month among water years, occurring later at deeper sites when colder water becomes warmer (Wheeler et al. 2018). In wetter years, delayed breeding into early July can occur in some colder snowmelt systems (S. Kupferberg and A. Lind pers. comm. 2017, GANDA 2018).

A population's period of oviposition can also vary from two weeks to three months, meaning they could be considered explosive breeders at some sites and prolonged breeders at others (Storer 1925, Zweifel 1955, Van Wagner 1996, Ashton et al. 1997, Wheeler and Welsh 2008). Water temperature typically warms to over 10°C (50°F) before breeding commences (GANDA 2008, Gonsolin 2010, Wheeler et al. 2018). Wheeler and Welsh (2008) observed Foothill Yellow-legged Frogs breeding when flows were below 0.6 m/s (2 ft/s), pausing during increased flows until they receded, and GANDA (2008) reported breeding initiated when flow decreased to less than 55% above baseflow.

Male Foothill Yellow-legged Frogs spend more time at breeding sites during the season than females, many of whom leave immediately after laying their eggs (GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010). Daily movements are usually short (< 0.3 m [1 ft]), but some individuals travel substantial distances: median 70.7 m/d (232 ft/d) in spring and 37.1 m/d (104 ft/day) in fall/winter, nearly always using streams as movement corridors (Van Wagner 1996, Bourque 2008, Gonsolin 2010). The maximum reported movement rate is 1,386 m/d (0.86 mi/d), and the longest seasonal (post-breeding) daily distance reported is 7.04 km (4.37 mi) by a female that traveled up a dry tributary and over a ridge before returning to and moving up the mainstem creek (Bourque 2008). Movements during the non-breeding season are typically in response to drying channels or during rain events (Bourque 2008, Gonsolin 2010, Cook et al. 2012).

Hatchling Foothill Yellow-legged Frogs tend to remain with what is left of the egg mass for several days before dispersing into the interstitial spaces in the substrate (Ashton et al. 1997). They often move downstream in areas of moderate flow and will follow the location of warm water in the channel throughout the day (Brattstrom 1962, Ashton et al. 1997, Kupferberg et al. 2011a). Tadpoles usually

metamorphose in late August or early September (S. Kupferberg and A. Lind pers. comm. 2017). Twitty et al. (1967) reported that newly metamorphosed Foothill Yellow-legged Frogs mostly migrated upstream, which may be an evolutionary mechanism to return to their natal site after being washed downstream (Ashton et al. 1997).

Home Range and Territoriality

Foothill Yellow-legged Frogs exhibit a lek-type mating system in which males aggregate at the breeding site and establish calling territories (Wheeler and Welsh 2008, Bondi et al. 2013). The species has a relatively large calling repertoire for western North American ranids with seven unique vocalizations recorded (Silver 2017). Some of these can be reasonably attributed to territory defense and mate attraction communications (MacTeague and Northen 1993, Silver 2017). Physical aggression among males during the breeding season has been reported (Rombough and Hayes 2007, Wheeler and Welsh 2008). In addition, Wheeler and Welsh (2008) observed a non-random mating pattern in which males engaged in amplexus with females were larger than males never seen in amplexus, suggesting either physical competition or female preference for larger individuals. Very little information has been published on Foothill Yellow-legged Frog home range size. Wheeler and Welsh (2008) studied males during a 17-day period during breeding season and classified some of them as "site faithful" based on their movements and calculated their home ranges. Two-thirds of males tracked were site faithful, and their mean home range size was 0.58 m^2 (SE = 0.10 m^2; 6.24 ft^2 [SE = 1.08 ft^2]) (Ibid.). In contrast, perhaps because the study took place over a longer time period, Bourque (2008) reported approximately half of the males he tracked during the spring were mobile, and the other half were sedentary. The median distances traveled along the creek (a proxy for home range size since they rarely leave the riparian corridor) for mobile and sedentary males were 149 m (489 ft) and 5.5 m (18 ft), respectively.

Diet and Predators

Foothill Yellow-legged Frog diet varies by life stage and likely body size. Tadpoles graze on periphyton (algae growing on submerged surfaces) scraped from rocks and vegetation and grow faster, and to a larger size, when it contains a greater proportion of epiphytic diatoms with nitrogen-fixing endosymbionts (*Epithemia* spp.), which are high in protein and fat (Kupferberg 1997b, Fellers 2005, Hayes et al. 2016, Catennazi and Kupferberg 2017). Tadpoles may also forage on necrotic tissue from dead bivalves and other tadpoles, or more likely the algae growing on them (Ashton et al. 1997, Hayes et al. 2016). Post-metamorphic Foothill Yellow-legged Frogs primarily feed on a wide variety of terrestrial arthropods but also some aquatic invertebrates (Fitch 1936, Van Wagner 1996, Haggarty 2006). Most of their diet consists of insects and arachnids (Van Wagner 1996, Haggarty 2006, Hothem et al. 2009). Haggarty (2006) did not identify any preferred taxonomic groups, but she noted larger Foothill Yellow-legged Frogs consumed a greater proportion of large prey items compared to smaller individuals, suggesting the species may be gape-limited generalist predators. Hothem et al. (2009) found mammal hair and bones in a Foothill Yellow-legged Frog. Adult Foothill Yellow-legged Frogs, like many other ranids, also cannibalize conspecifics (Wiseman and Bettaso 2007). In the fall when young-of-year are abundant, they may provide an important source of nutrition for adults prior to overwintering (Ibid.).

Foothill Yellow-legged Frogs are preyed upon by several native and introduced species, including each other as described above. Some predators target specific life stages, while others may consume multiple stages. Several species of garter snakes (genus *Thamnophis*) are the primary and most widespread group of native predators on Foothill Yellow-legged Frogs tadpoles through adults is (Fitch 1941, Fox 1952, Zweifel 1955, Lind and Welsh 1994, Ashton et al. 1997, Wiseman and Bettaso 2007, Gonsolin 2010). Table 1 lists other known and suspected predators of Foothill Yellow-legged Frogs.

Table 1. Confirmed and potential Foothill Yellow-legged Frog predators in California in addition to gartersnakes (*Thamnophis* spp.)

Common Name	Scientific Name	Classification	Native	Prey Life Stage(s)	Sources
Caddisfly (larva)	*Dicosmoecus gilvipes*	Insect	Yes	Embryos (eggs)	Rombough and Hayes 2005
Dragonfly (nymph)	*Aeshna walker*	Insect	Yes	Larvae	Catenazzi and Kupferberg 2018
Waterscorpion	*Ranatra brevicollis*	Insect	Yes	Larvae	Catenaazi and Kupferberg 2018
Signal Crayfish	*Pacifastacus leniusculus*	Crustacean	No	Embryos (eggs) and Larvae	Rombough and Hayes 2005; Wiseman et al. 2005
Speckled Dace	*Rhinichthys osculus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Reticulate Sculpin	*Cottus perplexus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Sacramento Pike Minnow	*Ptychocheilus grandis*	Fish	Yes*	Embryos (eggs) and Adults	Ashton and Nakamoto 2007
Sunfishes	Family Centrachidae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Catfishes	Family Ictaluridae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Rough-skinned Newt	*Taricha granulosa*	Amphibian	Yes	Embryos (eggs)	Evenden 1948
California Giant Salamander	*Dicamptodon ensatus*	Amphibian	Yes	Larvae	Fidenci 2006
American Bullfrog	*Rana catesbeiana*	Amphibian	No	Larvae to Adults	Crayon 1998; Hothem et al. 2009
California Red-legged Frog	*Rana draytonii*	Amphibian	Yes	Larvae to Adults	Gonsolin 2010
American Robin	*Turdus migratorius*	Bird	Yes	Larvae	Gonsolin 2010
Common Merganser	*Mergus merganser*	Bird	Yes	Larvae	Gonsolin 2010
American Dipper	*Cinclus mexicanus*	Bird	Yes	Larvae	Ashton et al. 1997
Mallard	*Anas platyrhynchos*	Bird	Yes	Adults	Rombough et al. 2005
Raccoon	*Procyon lotor*	Mammal	Yes	Larvae to Adults	Zweifel 1955; Ashton et al. 1997
River Otter	*Lontra canadensis*	Mammal	Yes	Adults	T. Rose pers. comm. 2014

* Introduced to the Eel River, location of documented predation; Foothill Yellow-legged Frogs are extirpated from most areas of historical range overlap

STATUS AND TRENDS IN CALIFORNIA

Administrative Status

Sensitive Species

The Foothill Yellow-legged Frog is listed as a Sensitive Species by the U.S. Bureau of Land Management (BLM) and U.S. Forest Service (Forest Service). These agencies define Sensitive Species as those species that require special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA.

California Species of Special Concern

The Department's Species of Special Concern (SSC) designation is similar to the federal Sensitive Species designation. It is administrative, rather than regulatory in nature, and intended to focus attention on animals at conservation risk. The designation is used to stimulate needed research on poorly known species and to target the conservation and recovery of these animals before they meet the CESA criteria for listing as threatened or endangered (Thomson et al. 2016). The Foothill Yellow-legged Frog is listed as a Priority 1 (highest risk) SSC (Ibid.).

Trends in Distribution and Abundance

Range-wide in California

Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551). Systematic, focused, range-wide assessments of Foothill Yellow-legged Frog distribution and abundance are rare, both historically and contemporarily. A detailed account of what has been documented within the National Parks and National Forests in California can be found in Appendix 3 of the *Foothill Yellow-legged Frogs Conservation Assessment in California* (Hayes et al. 2016).

Most Foothill Yellow-legged Frog records are incidental observations made during stream surveys for ESA-listed salmonids and simply document presence at a particular date and location, although some include counts or estimates of abundance by life stage. This makes assessing trends in distribution and abundance difficult despite a relatively large number of observations compared to many other species tracked by the California Natural Diversity Database (CNDDB). The CNDDB contained 2,366 Foothill Yellow-legged Frog occurrences in its March 2019 edition, 500 of which are documented from the past 5 years.

A few wide-ranging survey efforts that included Foothill Yellow-legged Frogs exist. Reports from early naturalists suggest Foothill Yellow-legged Frogs were relatively common in the Coast Ranges as far south as central Monterey County, in eastern Tehama County, and in the foothills in and near Yosemite National Park (Grinnell and Storer 1924, Storer 1925, Grinnell et al. 1930, Martin 1940). In addition to

these areas, relatively large numbers of Foothill Yellow-legged Frogs (17-35 individuals) were collected at sites in the central and southern Sierra Nevada and the San Gabriel Mountains between 1911 and 1950 (Hayes et al. 2016). Widespread disappearances of Foothill Yellow-legged Frog populations were documented as early as the 1970s and 80s in southern California, the southern Coast Range, and the central and southern Sierra Nevada foothills (Moyle 1973, Sweet 1983).

Twenty-five years ago, the Department published the first edition of *Amphibians and Reptile Species of Special Concern in California* (Jennings and Hayes 1994). The authors revisited hundreds of localities between 1988 and 1991 that had historically been occupied by Foothill Yellow-legged Frogs ~~between 1988 and 1991~~ and consulted local experts to determine presumed extant or extirpated status. Based on these survey results and stressors observed on the landscape, they considered Foothill Yellow-legged Frogs endangered in central and southern California south of the Salinas River in Monterey County. They considered the species threatened in the west slope drainages of the Cascade Mountains and Sierra Nevada east of the Central Valley, and they considered the remainder of the range to be of special concern (Ibid.).

Fellers (2005) and his field crews conducted surveys for Foothill Yellow-legged Frogs throughout California. They visited 804 sites across 40 counties with suitable habitat within the species' historical range. They detected at least one individual at 213 sites (26.5% of those surveyed) over 28 counties. They located Foothill Yellow-legged Frogs in approximately 40% of streams in the North Coast, 30% in the Cascade Mountains and south of San Francisco in the Coast Range, and 12% in the Sierra Nevada. Fellers estimated population abundance was 20 or more adults at only 14% of the sites where the species was found and noted the largest and most robust populations occurred along the North Coast. In addition, to determine status of Foothill Yellow-legged Frogs across the species' range and potential causes for declines, Lind (2005) used previously published status accounts, species expert and local biologist professional opinions, and field visits to historically occupied sites between 2000-2002. She determined that Foothill Yellow-legged Frogs had disappeared from 201 of 394 of the sites, representing just over 50%. The coarse-scale trend in California is one of greater population declines and extirpations in lower elevations and latitudes (Davidson et al. 2002).

Few site-specific population trend data are available from which to evaluate status. However, long-term monitoring efforts often use egg mass counts as a proxy to estimate adult breeding females. The results of these studies often reveal extreme interannual variability in number of egg masses laid (Ashton et al. 2010, S. Kupferberg and M. Power pers. comm. 2015, Peek and Kupferberg 2016). In a meta-analysis of egg mass count data collected across the species' range in California over the past 25 years, Peek and Kupferberg (2016) reported declines in two unregulated rivers and an increase in another. Their models did not detect any significant trends in abundance across different locations or regulation type (dammed or undammed); however, high interannual variability can render trend detection difficult. Interannual variability was substantially greater in regulated rivers vs. unregulated; the median coefficient of variation was 66.9% and 41.6%, respectively (Ibid.). The greater variability in regulated rivers decreases the probability of detecting significant declines, and coupled with low abundance, it can lead to populations dropping below a density necessary for persistence without detection, resulting in extirpation.

Regional differences in Foothill Yellow-legged Frog persistence across its range have been recognized for nearly 50 years (i.e., more extirpations documented in the south). Because of these differences and the recent availability of new landscape genomic data, more detailed descriptions of trends in Foothill Yellow-legged Frog population distribution and abundance in California are evaluated by clade below. Figure 5 depicts Foothill Yellow-legged Frog localities across all clades in California by the most recent confirmed sighting in the datasets available to the Department within a Public Lands Survey System (PLSS) section. “Transition Zones” are those areas where the exact clade boundaries are unknown due to a lack of samples. In addition, while not depicted as an area of uncertainty, no genetic samples have been tested south of the extant population in northern San Luis Obispo County, in the Sutter Buttes in Sutter County, or northeastern Plumas County. It is possible there were historically more clades than currently understood.

Caution should be exercised in comparing the following observation data across the species’ range and across time since survey effort and reporting are not standardized. These data can be useful for making some general inferences about distribution, abundance, and trends. For instance, assuming the observation correctly identifies the species, the date on the record is the last time the species was confirmed to have occurred at that location. However, this only works in the affirmative. For example, at a site where the last time the species was seen was 75 years ago, the species may still persist there if no one has surveyed it since the original observation. CNDDB staff use information on land use conversion, follow-up visits, and biological reports to categorize an occurrence location as “extirpated” or “possibly extirpated”.

Northwest/North Coast Clade

This clade extends from north of San Francisco Bay through the Coast Range and Klamath Mountains to the northern limit of the Foothill Yellow-legged Frog’s range and east through the Cascade Range. It includes Del Norte, Siskiyou, Humboldt, Trinity, Shasta, Tehama, Mendocino, Glenn, Colusa, Lake, Sonoma, Napa, Yolo, Solano, and Marin counties. This clade covers the largest geographic area and contains the greatest amount of genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). In addition, it is the only clade with an increasing trend in genetic diversity (Peek 2018).

Early records note the comparatively high abundance of Foothill Yellow-legged Frogs in this area. Storer (1925) described Foothill Yellow-legged Frogs as very common in many of Coast Range streams north of San Francisco Bay, and Cope (1879,1883 as cited in Hayes et al. 2016) noted they were “rather abundant in the mountainous regions of northern California.” In addition, relatively large collections occurred over short periods of time in this region in the late 1800s and the first half of the 20th century (Hayes et al. 2016). Nineteen were taken over two weeks in 1893 along Orrs Creek, a tributary to the Russian River, and 40 from near Willits (both in Mendocino County) in 1911; 112 were collected over three days at Skaggs Spring (Sonoma County) in 1911; 57 were taken in one day along Lagunitas Creek (Marin County) in 1928; and 50 were collected in one day near Denny (Trinity County) in 1955 (Ibid.).

A few long-term Foothill Yellow-legged Frog egg mass monitoring efforts undertaken within this clade’s boundaries found densities vary significantly, often based on river regulation type, and documented

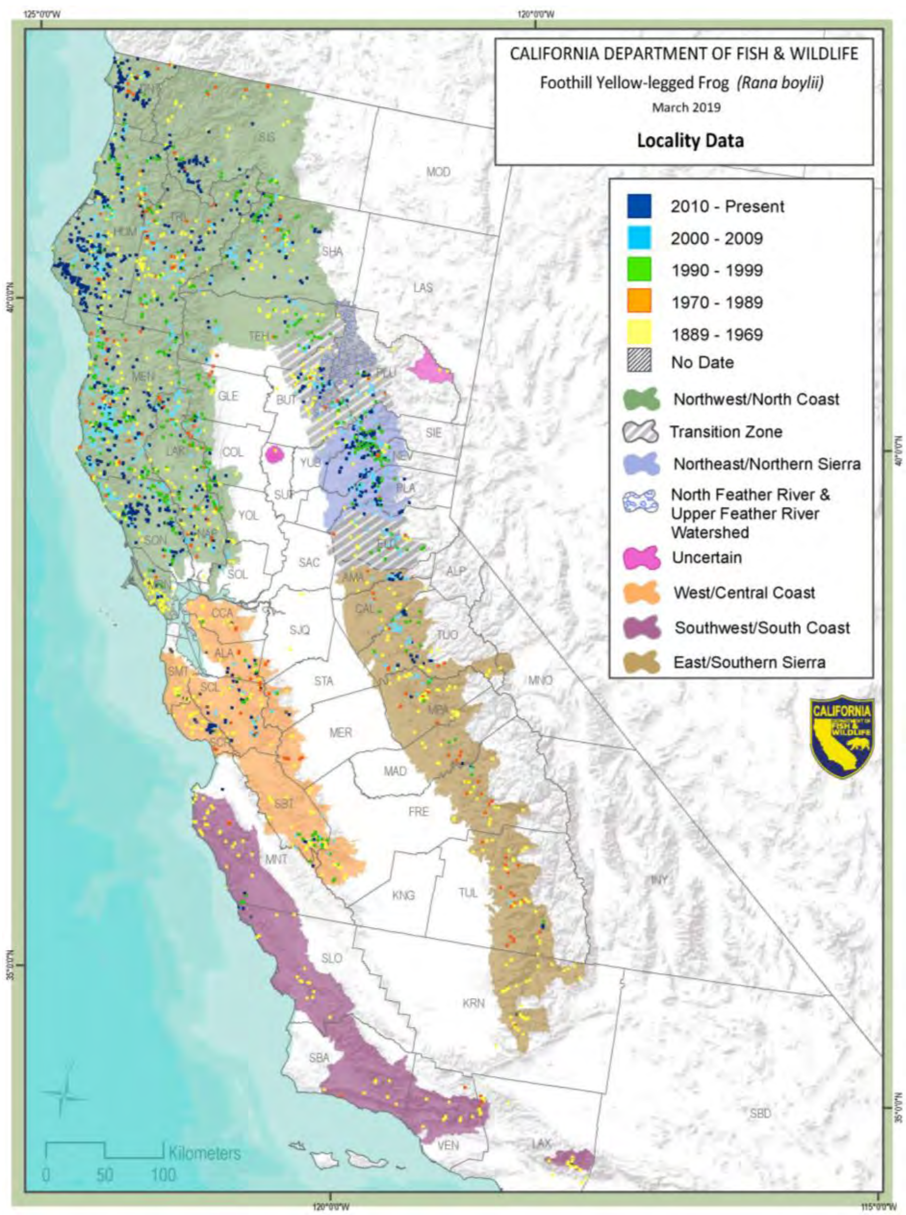

Figure 5. Foothill Yellow-legged Frog occurrence data from 1889-2019 overlaying the six clades by most recent sighting in a Public Lands Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

several robust populations. The Green Diamond Resources Company has been monitoring a stretch of the Mad River near Blue Lake (Humboldt County) since 2008 (GDRC 2018). The greatest published density of Foothill Yellow-legged Frog egg masses was documented here in 2009 at 323.6 egg masses/km (520.7/mi) (Bourque and Bettaso 2011). However, in 2017, surveyors counted 625.1 egg masses/km (1,006/mi) along the same reach (GDRC 2018). At its lowest during this period, egg mass density was calculated at 71.54/km (115.1/mi) in 2010, although this count occurred after a flooding event that likely scoured over half of the egg masses laid that season (GDRC 2018, R. Bourque pers. comm. 2019). During a single day survey in 2017 along approximately 2 km (1.3 mi) of Redwood Creek in Redwood National Park (Humboldt County), 2,009 young and 126 adult Foothill Yellow-legged Frogs were found (D. Anderson pers. comm. 2017). Some reaches of the South Fork Eel River (Mendocino County) also support high densities of Foothill Yellow-legged Frogs. Kupferberg (pers. comm. 2018) recorded 206.9 and 106.2 egg masses/km (333 and 171/mi) along two stretches in 2016, and 201.7 and 117.5 egg masses/km (324 and 189/mi) in 2017. However, other reaches yielded counts as low as 6.1 and 8.4 egg masses/km (9.8 and 13.5/mi) (Ibid.). In the Angelo Reserve (an unregulated reach), the 24-year mean density was 109 egg masses/km (175.4/mi) (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015). In contrast, a 10-year mean density of egg masses below Lewiston Dam on the Trinity River (Trinity County) was 0.89/km (1.43/mi) (Ibid.).

Figure 6 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, Biological Information Observation System datasets, and personal communications that are color coded by the most recent date of detection. Within this clade, Foothill Yellow-legged Frogs were observed in at least 343 areas in the past 5 years (CNDDB 2019). The species remains widespread within many watersheds, although most observations only verify presence, or fewer than ten individuals or egg masses are recorded (Ibid.). Documented extirpations are comparatively rare, but also likely undetected or under-reported, and nearly all occurred just north of the high-populated San Francisco Bay area (Figure 7; Ibid.).

West/Central Coast

This clade extends south from the San Francisco Bay through the Diablo Range and down the peninsula through the Santa Cruz and Gabilan Mountains in the Coast Range east of the Salinas Valley. It includes most of Contra Costa, Alameda, San Mateo, Santa Cruz, Santa Clara, and San Benito counties; western San Joaquin, Stanislaus, Merced, and Fresno counties; and a small portion of eastern Monterey County. Records of Foothill Yellow-legged Frogs occurring south of San Francisco Bay did not exist until specimens were collected in 1918 around what is now Pinnacles National Park in San Benito County, and little information exists on historical distribution and abundance within this clade (Storer 1923).

Within this clade, Foothill Yellow-legged Frogs were observed in at least 24 areas in the past five years (Figure 8; CNDDB 2019). Documented and possible extirpations are concentrated around the San Francisco Bay and sites at the southern portion of the clade's range, although these may not have been resurveyed since their original observations in the 1940s through 1960s, except for a site in Pinnacles National Park that was surveyed in 1994 (Figure 9; Ibid.). In addition, although not depicted,

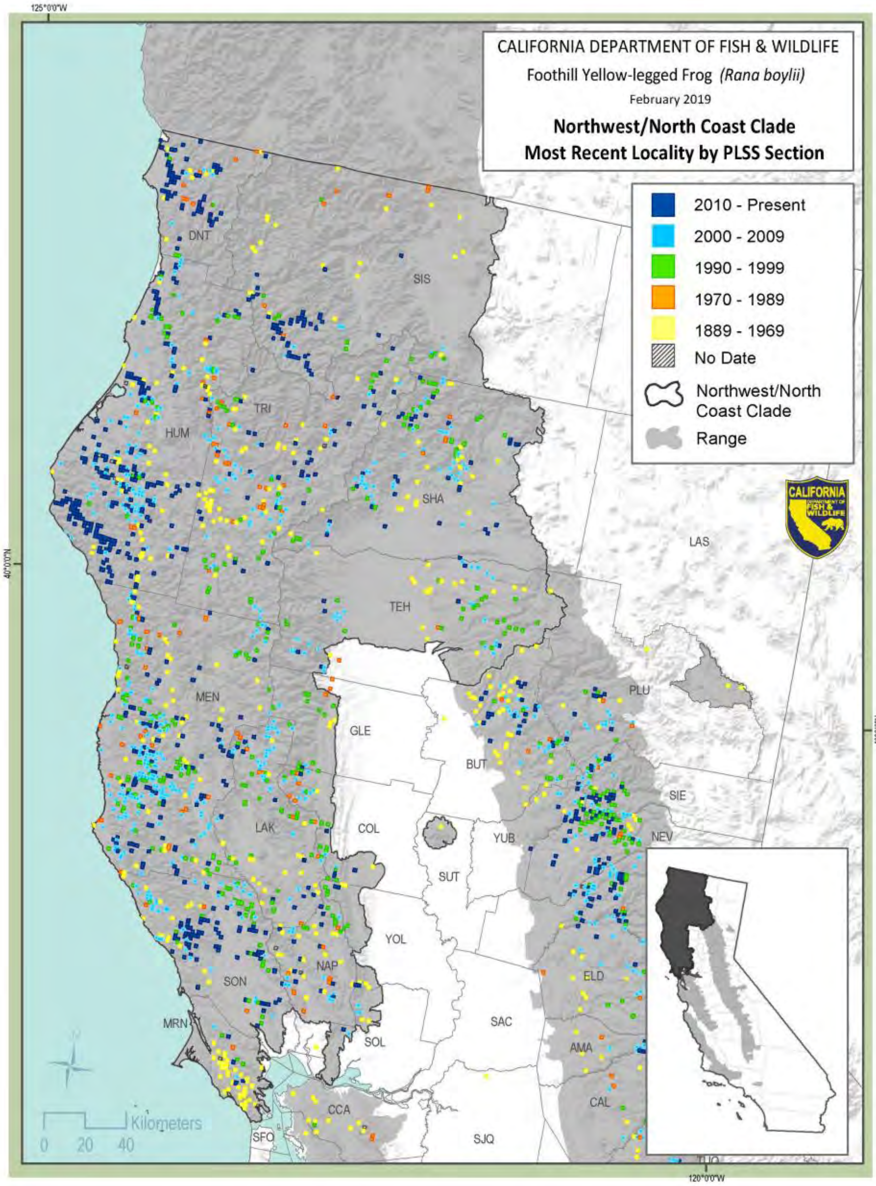

Figure 6. Close-up of Northwest/North Coast Foothill Yellow-legged Frog clade observations from 1889-2019 (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

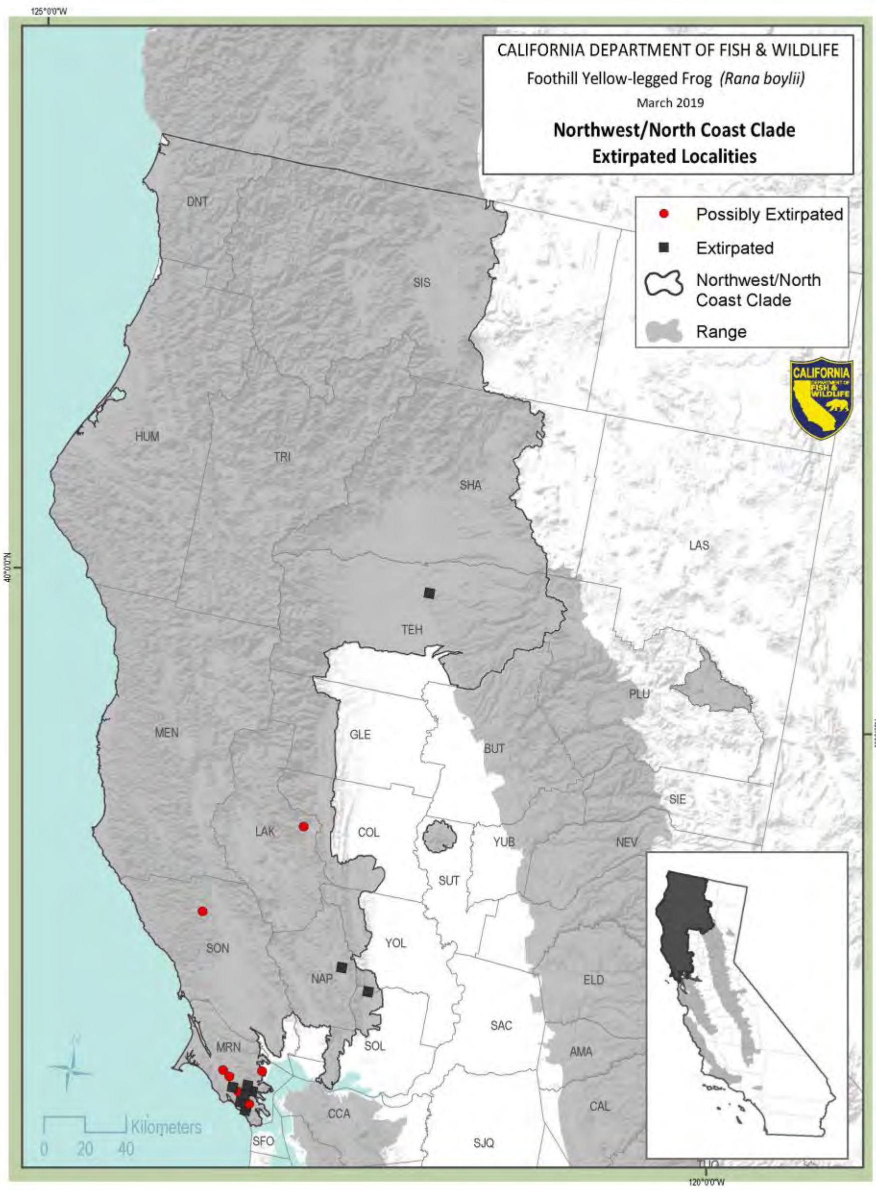

Figure 7. Possibly extirpated and extirpated Northwest/North Coast Foothill Yellow-legged Frog clade sites (CNDDB)

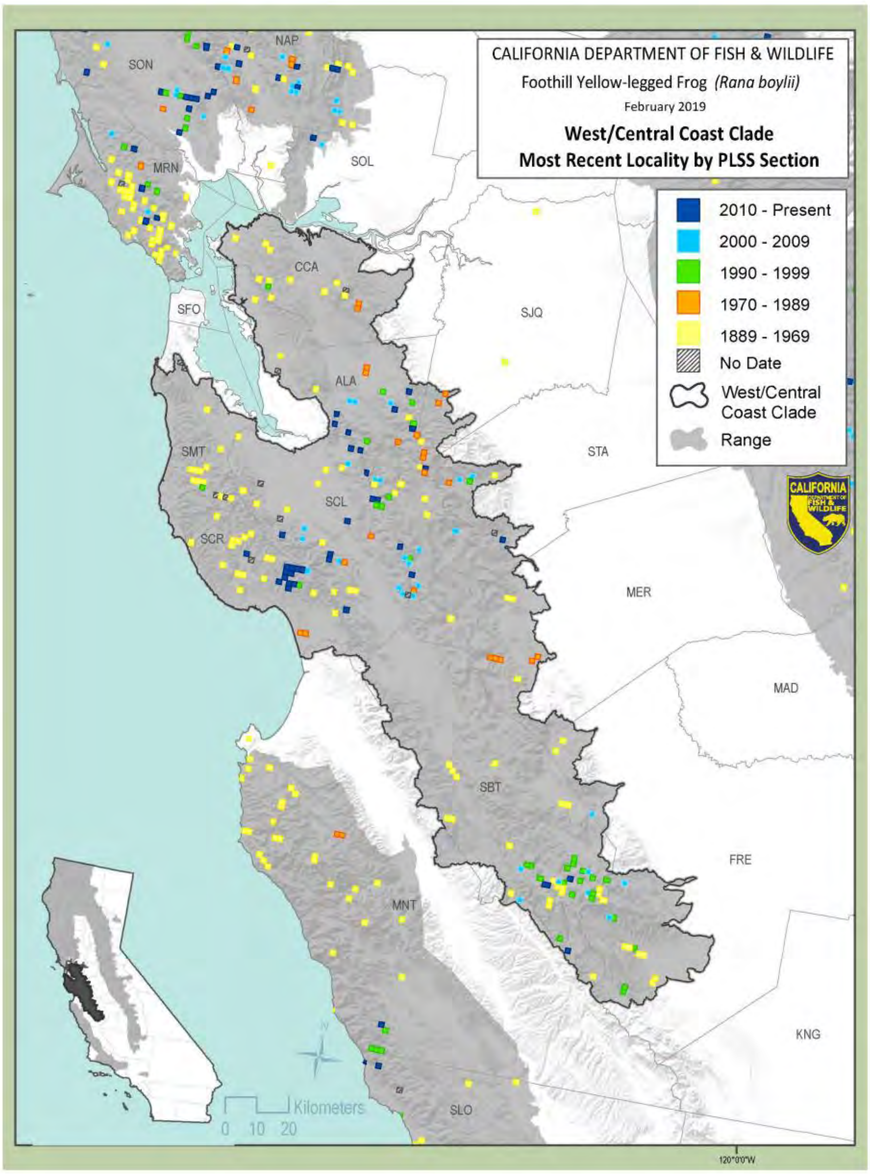

Figure 8. Close-up of West/Central Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

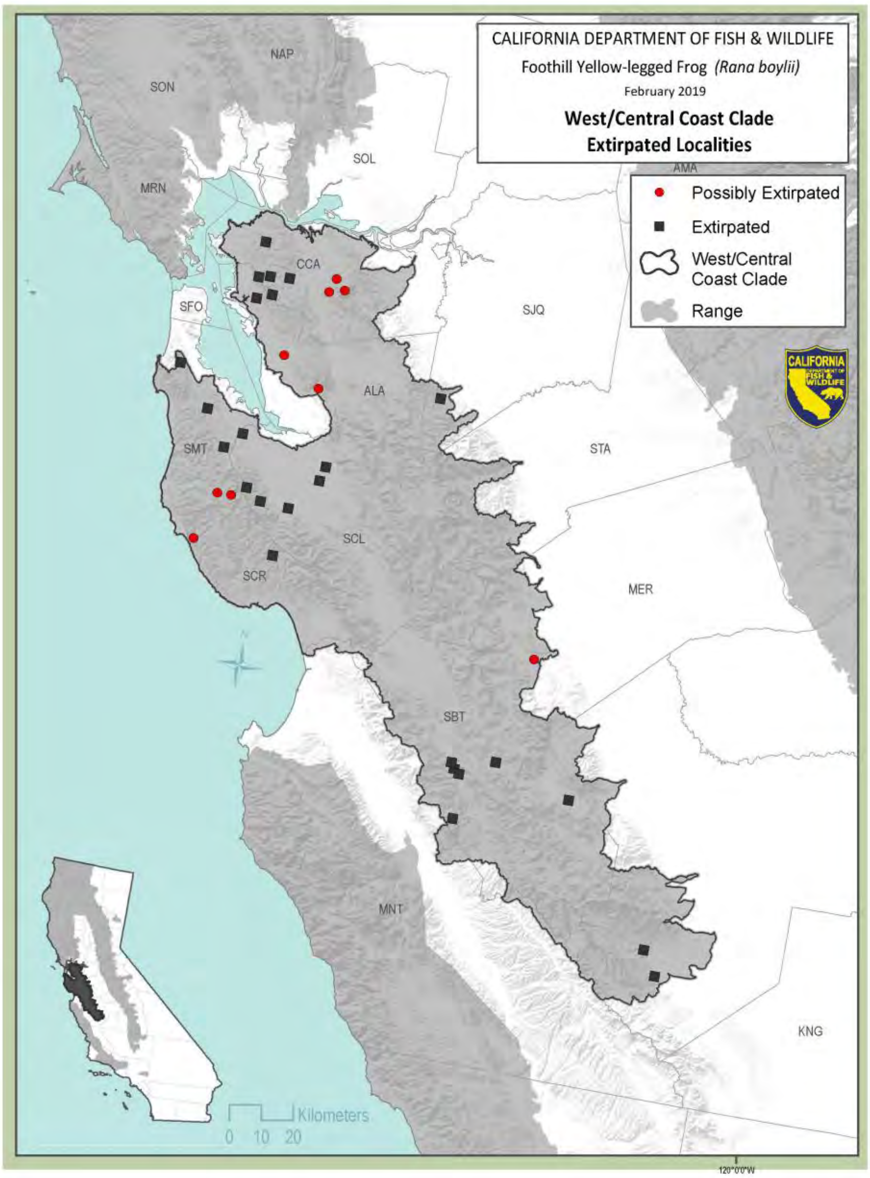

Figure 9. Possibly extirpated and extirpated West/Central Coast Foothill Yellow-legged Frog clade sites (CNDDB)

two populations on Arroyo Mocho and Arroyo Valle south of Livermore (Alameda County) are also likely extirpated (M. Grefsrud pers. comm. 2019).

The San Francisco Bay Area is heavily urbanized. Foothill Yellow-legged Frogs may be gone from Contra Costa County; eight of the nine CNDDB records from the county are museum specimens collected between 1891 and 1953, and the most recent observation was two adults in a plunge pool in an intermittent tributary to Moraga Creek in 1997. No recent (2010 or later) observations exist from San Mateo County (Ibid.). Historically occupied lower-elevation sites surrounding the San Francisco Bay and inland appear to be extirpated, but there are (or were) some moderately abundant breeding populations remaining at higher elevations in Arroyo Hondo (Alameda County), Alameda Creek (Alameda and Santa Clara counties), Coyote and Upper Llagas creeks (Santa Clara County), and Soquel Creek (Santa Cruz County) with some scattered smaller populations also persisting in these counties (J. Smith pers. comm. 2016, 2017; CNDDB 2019). The Alameda Creek and Coyote Creek populations recently underwent large-scale mortality events, so their numbers are likely substantially lower than what is currently reported in the CNDDB (Adams et al. 2017a, Kupferberg and Catenazzi 2019). In addition, the Arroyo Hondo population will lose approximately 1.6 km (1 mi) of prime breeding habitat (i.e., ~~supported~~ supporting the highest density of egg masses on the creek) as the Calaveras Reservoir is refilled following its dam replacement project in 2019 (M. Grefsrud pers. comm. 2019). Foothill Yellow-legged Frogs may be extirpated from Corral Hollow Creek in San Joaquin County, but a single individual was observed five years ago further up the drainage in Alameda County within an Off-Highway Vehicle park (CNDDB 2019). Few recent sightings of Foothill Yellow-legged Frogs in the east-flowing creeks are documented. They may still be extant in the headwaters of Del Puerto Creek (western Stanislaus County), but the records further downstream indicate bullfrogs (known predators and disease reservoirs) are moving up the system (Ibid.). Several locations in southern San Benito, western Fresno, and eastern Monterey counties have relatively recent (2000 and later) detections (Ibid.). However, while many of these sites supported somewhat large populations in the 1990s, the more recent records report fewer than ten individuals (Ibid.). The exception is a Monterey County site where around 25 to 30 were observed in 2012 (Ibid.).

Southwest/South Coast

Widespread extirpations occurred decades ago, primarily in the 1960s and 1970s, in this area (Adams et al. 2017b). As a result, genetic samples were largely unavailable, and the boundaries are speculative. The clade is presumed to include the Coast Range from Monterey Bay south to the Transverse Range across to the San Gabriel Mountains. This clade includes portions of Monterey, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties. Storer (1923) reported that Foothill Yellow-legged Frogs were collected for the first time in Monterey County in 1919 and that a specimen collected by Cope in 1889 in Santa Barbara and listed as *Rana temporaria pretiosa* may refer to the Foothill Yellow-legged Frog because as previously mentioned, the taxonomy of this species changed several times over the first century after it was named.

Foothill Yellow-legged Frogs had been widespread and fairly abundant in this area until the late 1960s (Figure 10) but were rapidly extirpated throughout the southern Coast Ranges and western Transverse

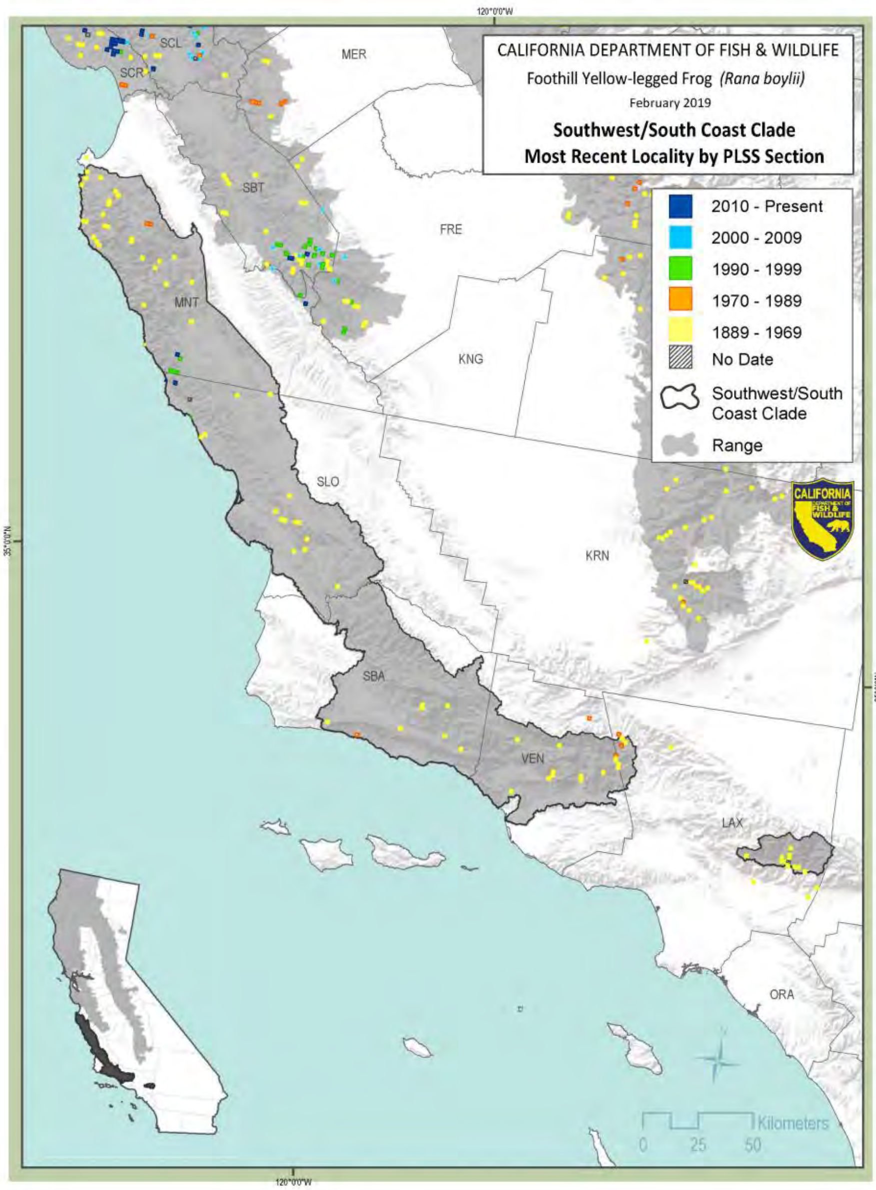

Figure 10. Close-up of Southwest/South Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

Ranges by the mid-1970s (Figure 11; Sweet 1983, Adams et al. 2017b). Only two known extant populations exist from this clade, located near the border of Monterey and San Luis Obispo counties (S. Sweet pers. comm. 2017, McCartney-Melstad et al. 2018, Peek 2018, CNDDB 2019). They appear to be extremely small and rapidly losing genetic diversity, making them at high risk of extirpation (McCartney-Melstad et al. 2018, Peek 2018).

Northeast/Feather River and Northern Sierra

The exact clade boundaries in the Sierra Nevada are unclear and will require additional sampling and testing to define (Figure 12). The Northeast clade presumably encompasses the Feather River and Northern Sierra clades. The Feather River clade is located primarily in Plumas and Butte counties. The Northern Sierra clade roughly extends from the Feather River watershed south to the Middle Fork American River. It includes portions of El Dorado, Placer, Nevada, Sierra, and Plumas counties. It may also include portions of Amador, Butte, and eastern Tehama counties. No genetic samples were available to test in the Sutter Buttes or the disjunct population in northeastern Plumas County to determine which clades they belonged to before they were extirpated (Figure 13; Olson et al. 2016, CNDDB 2019).

In general, there is a paucity of historical Foothill Yellow-legged Frog data for west-slope Sierra Nevada streams, particularly in the lower elevations of the Sacramento Valley, and no quantitative abundance data exist prior to major changes in the landscape (i.e., mining, dams, and diversions) or the introduction of non-native species (Hayes et al. 2016). Foothill Yellow-legged Frogs ~~have been~~were collected frequently from the Plumas National Forest area in small numbers from the turn of the 20th century through the 1970s (Ibid.). Estimates of relative abundance are not clear from the records, but they suggest the species was somewhat widespread in this area.

More recently, Foothill Yellow-legged Frog populations in the Sierra Nevada have been the subject of a substantial number of surveys and focused research associated with recent and ongoing relicensing of hydroelectric power generating dams by the Federal Energy Regulatory Commission (FERC). Consequently, Foothill Yellow-legged Frogs have been observed in at least 30 areas in Plumas and Butte counties (roughly the Feather River clade) over the past five years (CNDDB 2019). As with the rest of the range, most records are observations of only a few individuals; however, many observations occurred over multiple years, and in some cases all life stages were observed over multiple years (Ibid). The populations appear to persist even with the small numbers reported. The only long-term consistent survey effort has been occurring on the North Fork Feather River along the Cresta and Poe reaches (GANDA 2018). The Cresta reach's subpopulation declined significantly in 2006 and never recovered despite modification of the flow regime to reduce egg mass and tadpole scouring and some habitat restoration (Ibid.). A pilot project to augment the Cresta reach's subpopulation through in situ captive rearing was initiated in 2017 (Dillingham et al. 2018). It resulted in the highest number of young-of-year Foothill Yellow-legged Frogs recorded during fall surveys since researchers started keeping count (Ibid.). The number of egg masses laid in the Poe reach varies substantially year-to-year from a low of 26 in 2001 to a high of 154 in 2015 and back down to 36 in 2017 (GANDA 2018).

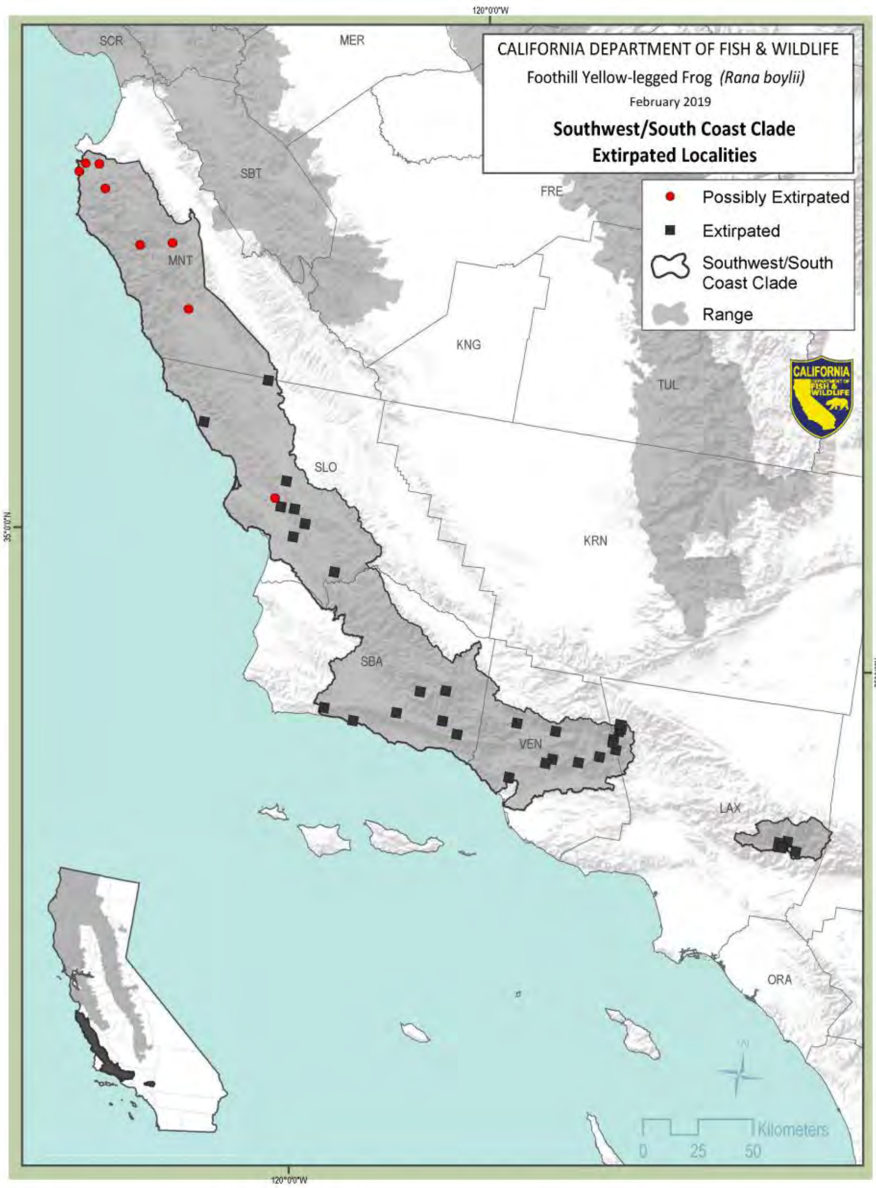

Figure 11. Possibly extirpated and extirpated Southwest/South Coast Foothill Yellow-legged Frog clade sites (CNDDB)

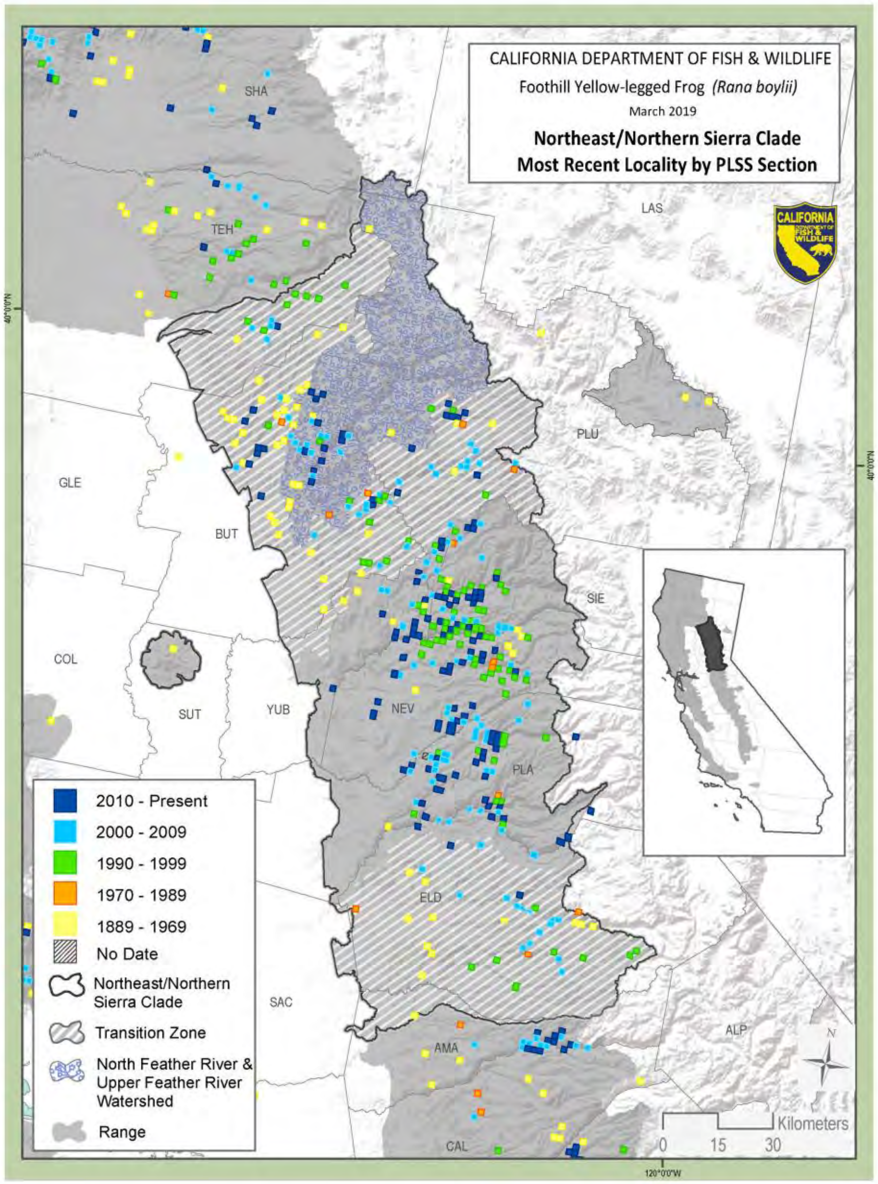

Figure 12. Close-up of Northeast/Feather River and Northern Sierra clades observations from 1889-2019 (ARSSC, BIOS, CNDDB)

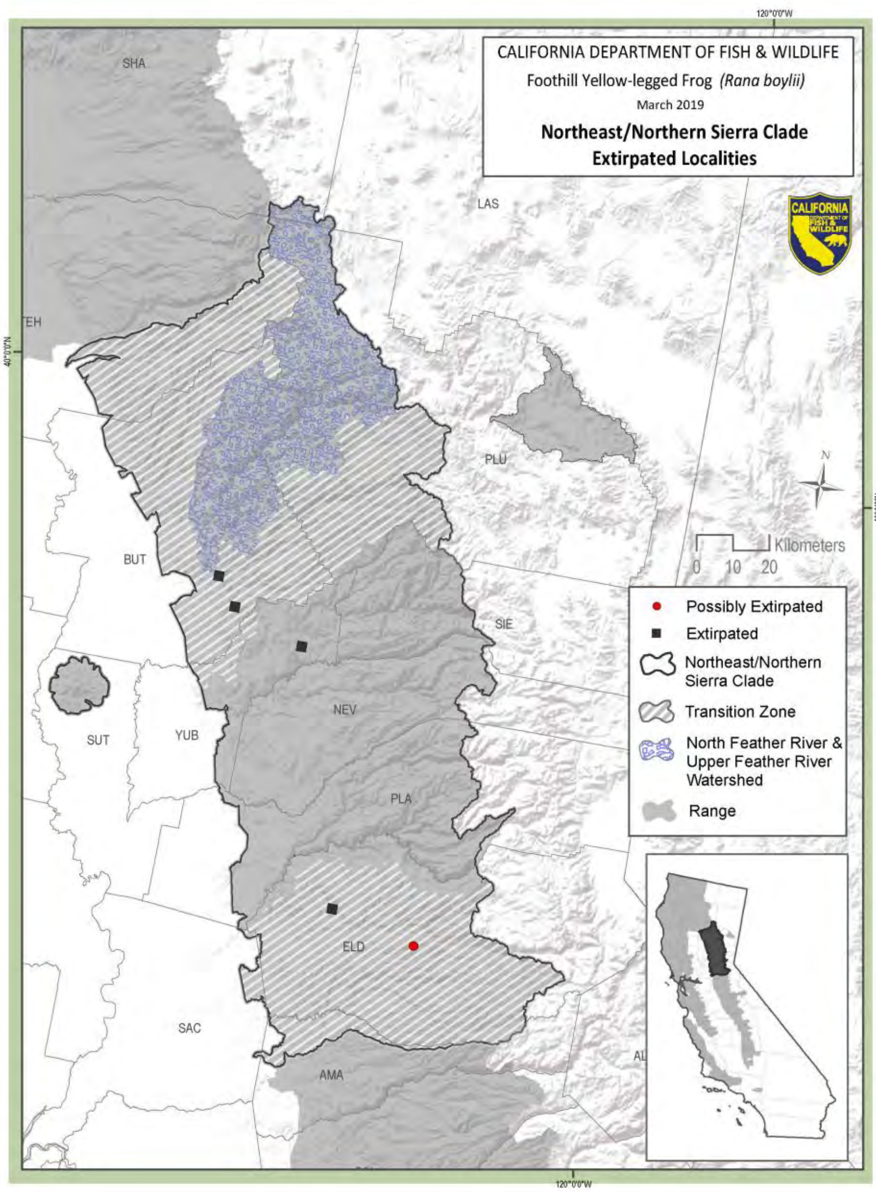

Figure 13. Possibly extirpated and extirpated Northeast/Feather River and Northern Sierra Foothill Yellow-legged Frog clades sites (CNDDB)

Foothill Yellow-legged Frogs have been observed in at least 71 areas in the past 5 years in the presumptive Northeast/Northern Sierra clade. The general pattern in this clade, and across the range for that matter, is that unregulated rivers or reaches have more areas that are occupied more consistently and in larger numbers than regulated rivers or reaches (CNDDB 2019, S. Kupferberg pers. comm. 2019). Foothill Yellow-legged Frogs were rarely observed in the hydropeaking reach of the Middle Fork American River and were observed in low numbers in the bypass reach, but they were present and breeding in small tributary populations (PCWA 2008). Relatively robust populations appear to inhabit the North Fork American River and Lower Rubicon River (Gaos and Bogan 2001, PCWA 2008, Hogan and Zuber 2012, K. Kundargi pers. comm. 2014, S. Kupferberg pers. comm. 2019). Additional apparently sufficiently large and relatively stable populations occur on Clear Creek, South Fork Greenhorn Creek, and Shady Creek (Nevada County) and the North and Middle Yuba River (Sierra County), but the remaining observations are of small numbers in tributaries with minimal connectivity among them (CNDDB 2019, S. Kupferberg pers. comm. 2019).

East/Southern Sierra

The East/Southern Sierra clade is presumed to range from the South Fork American River watershed, the northernmost site where individuals from this clade were collected, south to where the Sierra Nevada meets the Tehachapi Mountains. It likely includes El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, Fresno, Tulare, and Kern counties (Figure 14; Peek 2018). The proportion of extirpated sites in this clade is second only to the Southwest/South Coast and follows the pattern of greater losses in the south (Figure 15). Like the southern coastal clade, the southern Sierra clade has low genetic variability and a trajectory of continued loss of diversity (Ibid.).

Historical collections of small numbers of Foothill Yellow-legged Frogs occurred in every major river system within this clade beginning as early as the turn of the 20th century, indicating widespread distribution but little information on abundance (Hayes et al. 2016). By the early 1970s, declines in Foothill Yellow-legged Frog populations from this area were already apparent; Moyle (1973) found them at 30 of 95 sites surveyed in 1970. Notably bullfrogs inhabited the other 65 sites formerly occupied by Foothill Yellow-legged Frogs, and they co-occurred at only 3 sites (Ibid.). In 1992, Drost and Fellers (1996) revisited the sites around Yosemite National Park (Tuolumne and Mariposa counties) that Grinnell and Storer (1924) surveyed in 1915 and 1919. Foothill Yellow-legged Frogs had disappeared from all seven historically occupied sites and were not found at any new sites surveyed surrounding the park (Ibid.). Resurveys of previously occupied sites on the Stanislaus (Tuolumne County), Sierra (Fresno County), and Sequoia (Tulare County) National Forests were also undertaken (Lind et al. 2003b). Foothill Yellow-legged Frogs were absent from the sites in Sierra and Sequoia National Forests, six at each forest; however, a new population was discovered in the Sierra and two in the Sequoia forests (Ibid.). These populations remain extant but are small and isolated (CNDDB 2019). Two of the six sites on the Stanislaus were still occupied, and 19 new populations were found with evidence of breeding at seven of them (Lind et al. 2003b). Twenty of the 24 populations extant at the time inhabited unregulated waterways (Ibid.). Most of the CNDDB (2019) records of Foothill Yellow-legged Frogs on the Stanislaus are at least a decade old and are represented by low numbers.

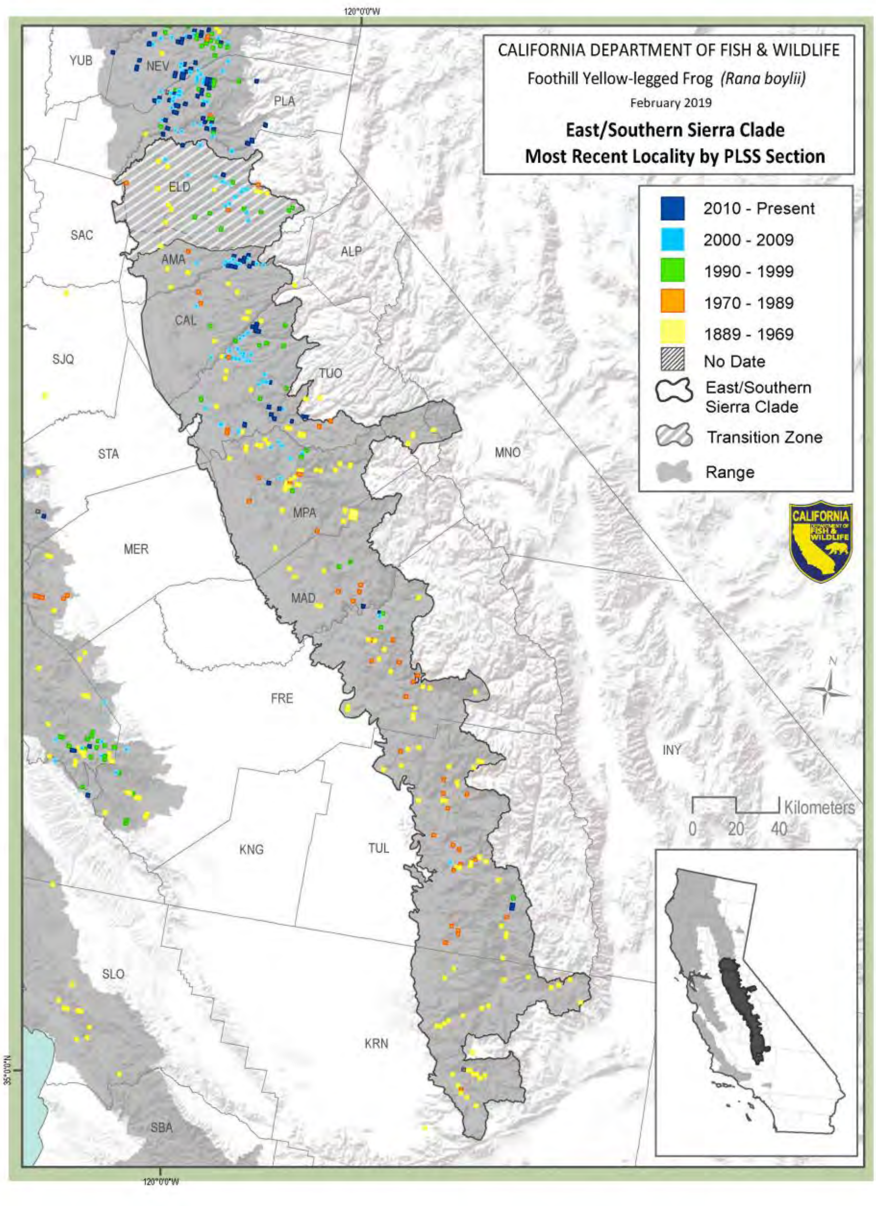

Figure 14. Close-up of East/Southern Sierra clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

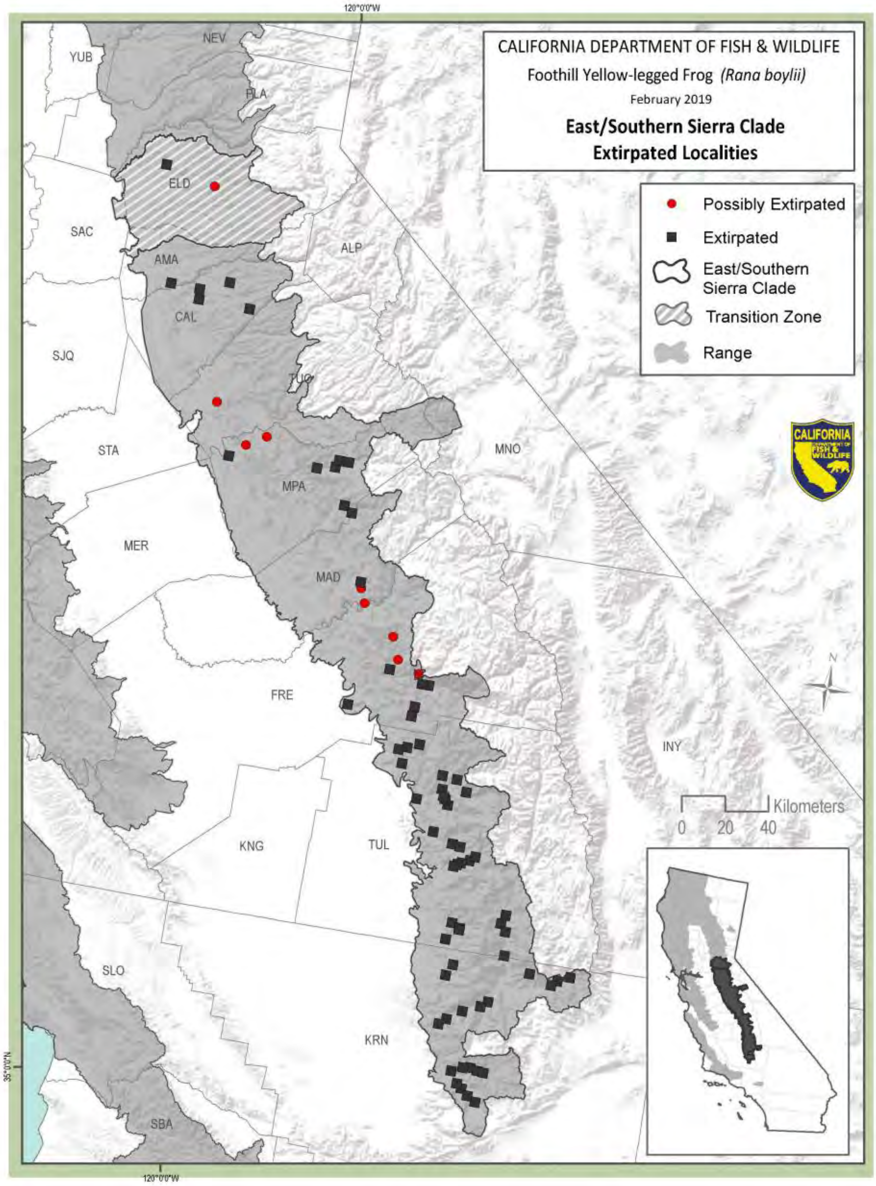

Figure 15. Possibly extirpated and extirpated East/Southern Sierra Foothill Yellow-legged Frog clade sites (CNDDB)

More recently, surveys for Foothill Yellow-legged Frogs were conducted along the South Fork American River as part of the El Dorado Hydroelectric Project's FERC license amphibian monitoring requirements (GANDA 2017). Between 2002 and 2016 counts of different life stages varied significantly by year but the trend for every life stage was a decline over that period (Ibid.). There appears to be a small population persisting along the North Fork Mokelumne River (Amador and Calaveras counties), but it was only productive during the 2012-2014 drought years (Ibid.). Small numbers have also been observed recently in several locations on private timberlands in Tuolumne County (CNDDB 2019).

FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

"The fortunes of the boylii *population fluctuate with those of the stream"* - Tracy I. Storer, 1925

Several past and ongoing activities have changed the watersheds upon which Foothill Yellow-legged Frogs depend, and many interact with each other exacerbating their adverse impacts. With such an expansive range in California, the degree and severity of these impacts on the species often vary by location. To the extent feasible based on the best scientific information available, those differences are discussed below.

Dams, Diversions, and Water Operations

Foothill Yellow-legged Frogs evolved in a Mediterranean climate with predictable cool, wet winters and hot, dry summers, ~~with~~ and their life cycle is adapted to these conditions. In California and other areas with a Mediterranean climate, human demands for water are at the highest when runoff and precipitation are lowest, and annual water supply varies significantly but always follows the general pattern of peak discharge declining to baseflow in the late spring or summer (Grantham et al. 2010). The Foothill Yellow-legged Frog's life cycle depends on this discharge pattern and the specific habitat conditions it produces (see the Breeding and Rearing Habitat section). Dams are ubiquitous, but not evenly distributed, in California. Figure 16 depicts the locations of dams under the jurisdiction of the Army Corps of Engineers (ACOE) and the California Department of Water Resources (DWR). Figure 17 depicts the number of surface diversions per PLSS section within the Foothill Yellow-legged Frog's range (eWRIMS 2019).

Dam operations frequently change the amount and timing of water availability; its temperature, depth, and velocity; and its sediment transport and channel morphology altering functions, which can result in dramatic consequences ~~on~~ for the Foothill Yellow-legged Frog's ability to survive and successfully reproduce. Several studies comparing Foothill Yellow-legged Frog populations in regulated and unregulated reaches within the same watershed investigate potential dam-effects. These studies demonstrated that dams and their operations can result in several factors that contribute to population declines and possible extirpation. These factors include confusing breeding cues, scouring and stranding of egg masses and tadpoles, reduced quality and quantity of breeding and rearing habitat, reduced tadpole growth rate, barriers to gene flow, and establishment and spread of non-native species (Hayes et al. 2016). In addition, as previously discussed in the Population Structure and Genetic Diversity section, subpopulations of Foothill Yellow-legged Frogs on regulated rivers are more isolated, and the

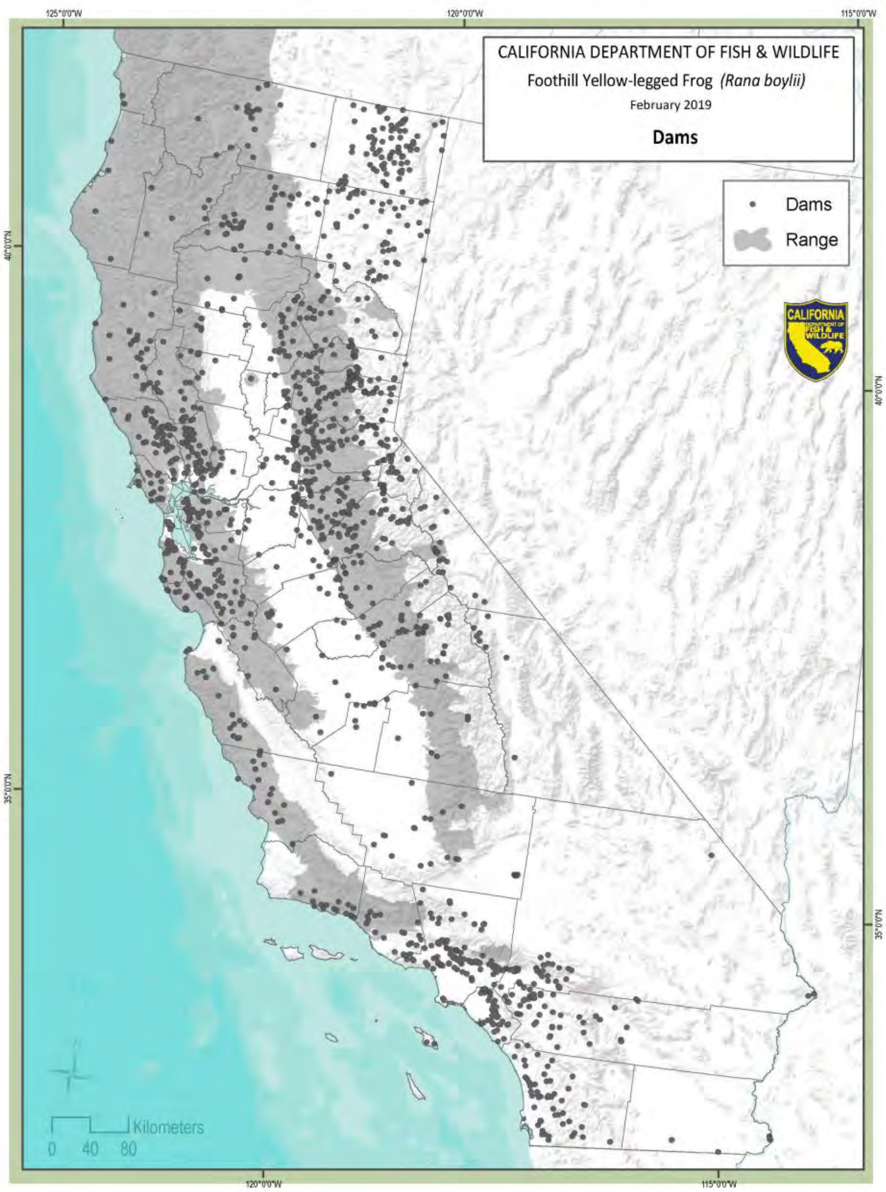

Figure 16. Locations of ACOE and DWR jurisdictional dams (DWR, FRS)

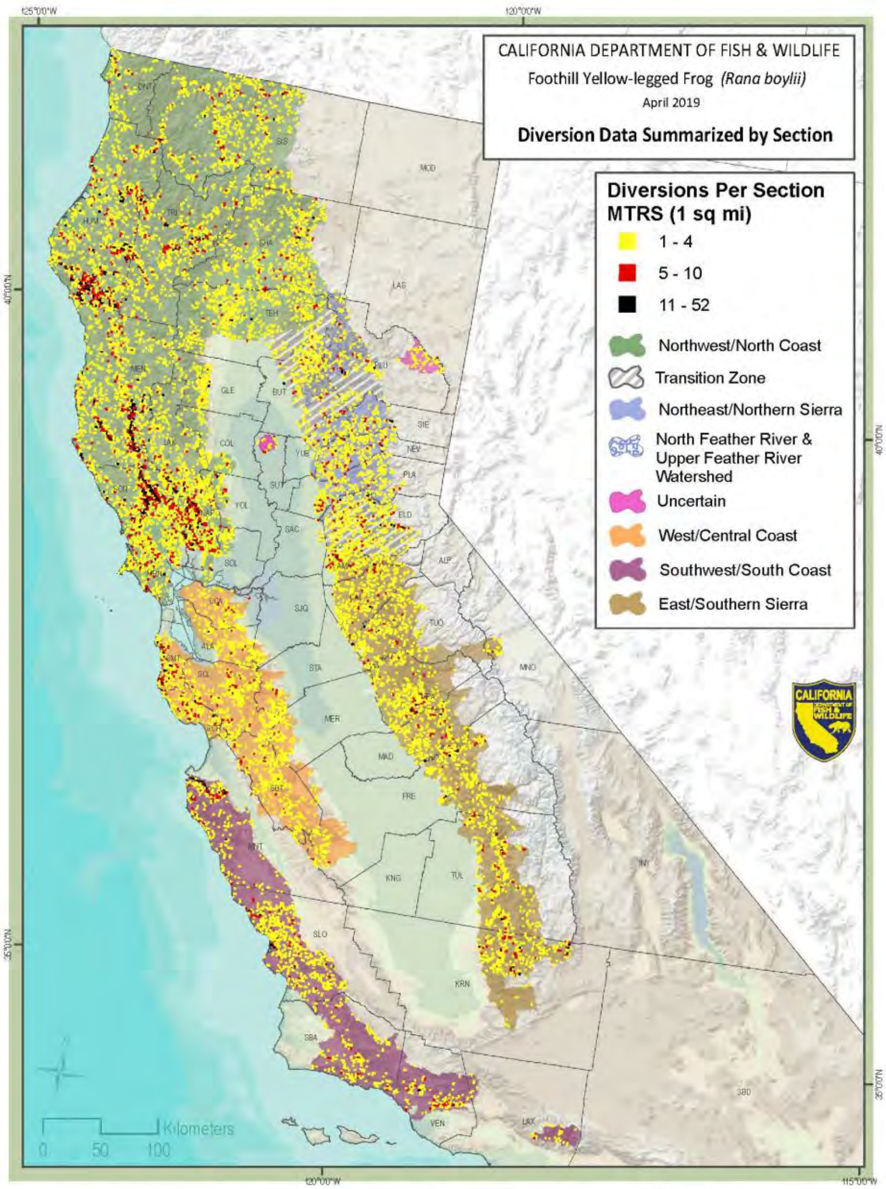

Figure 17. Number of surface water diversions per Public Lands Survey System section within the Foothill Yellow-legged Frog's range in California (eWRIMs)

type of water operations (hydropeaking vs. bypass flows) significantly affects the degree of gene flow loss among them (Peek 2011, 2018). Figure 18 depicts the locations of hydroelectric power plants.

As discussed in the Seasonal Activity and Movements section, cues for Foothill Yellow-legged Frogs to start breeding appear to involve water temperature and velocity, two features altered by dams. Dam operations typically result in reduced flows that are more stable over the course of a year than unimpaired conditions, and dam managers are frequently required to maintain thermally appropriate water temperatures and flows for cold-water-adapted salmonids (USFWS and Hoopa Valley Tribe 1999, Wheeler et al. 2014). For example, late-spring and summer water temperatures on the mainstem Trinity River below Lewiston Dam have been reported to be up to 10°C (20°F) cooler than average pre-dam temperatures, while average winter temperatures are slightly warmer (USFWS and Hoopa Valley Tribe 1999). As a result, Foothill Yellow-legged Frogs breed later on the mainstem Trinity River compared to six nearby tributaries, and some mainstem reaches may never attain the minimum required temperature for breeding (Wheeler et al. 2014, Snover and Adams 2016). In addition, annual discharges past Lewiston Dam have been 10-30% of pre-dam flows and do not mimic the natural hydrograph (Lind et al. 1996).

Aseasonal discharges from dams occur for several reasons including increased flow in late-spring and early summer to facilitate outmigration of salmonids, channel maintenance pulse flows, short-duration releases for recreational whitewater boating, rapid reductions after a spill (uncontrolled flows released down a spillway when reservoir capacity is exceeded) to retain water for power generation or water supply later in the year, peaking flows for hydroelectric power generation, and sustained releases to maintain the seismic integrity of the dam (Lind et al. 1996, Jackman et al. 2004, Kupferberg et al. 2011b, Kupferberg et al. 2012, Snover and Adams 2016). The results of a Foothill Yellow-legged Frog population viability analysis (PVA) suggest that the likelihood a population will persist is very sensitive to early life stage mortality; the 30-year probability of extinction increases significantly with high levels of egg or tadpole scouring or stranding (Kupferberg et al. 2009c). For instance, in 1991 and 1992, all egg masses laid before high flow releases to encourage outmigration of salmonids on the Trinity River were scoured away (Lind et al. 1996). According to the PVA, even a single annual pulse flow such as this or for recreational boating, can result in a three- to five-fold increase in the 30-year extinction risk based on amount of tadpole mortality experienced (Kupferberg et al. 2009c). Management after natural spills can also lead to substantial mortality. For example, in 2006, Foothill Yellow-legged Frogs on the North Fork Feather River bred during a prolonged spill, and the rapid recession below Cresta Dam that followed stranded and desiccated all the eggs laid (Kupferberg et al. 2009b). Rapid flows can also increase predation risk if tadpoles are forced to seek shelter under rocks where crayfish and other invertebrate predators are more common or if they are displaced into the water column where their risk of predation by fish is greater (Ibid.).

The overall reduction of flows and frequency of large winter floods below dams can produce extensive changes to Foothill Yellow-legged Frog habitat quality. They reduce the formation of river bars that are regularly used as breeding habitat, and they create deeper and steeper channels with less complexity and fewer warm, calm, shallow edge-water habitats for tadpole rearing (Lind et al. 1996, Wheeler and Welsh 2008, Kupferberg et al. 2011b, Wheeler et al. 2014). For example, 26 years after construction of

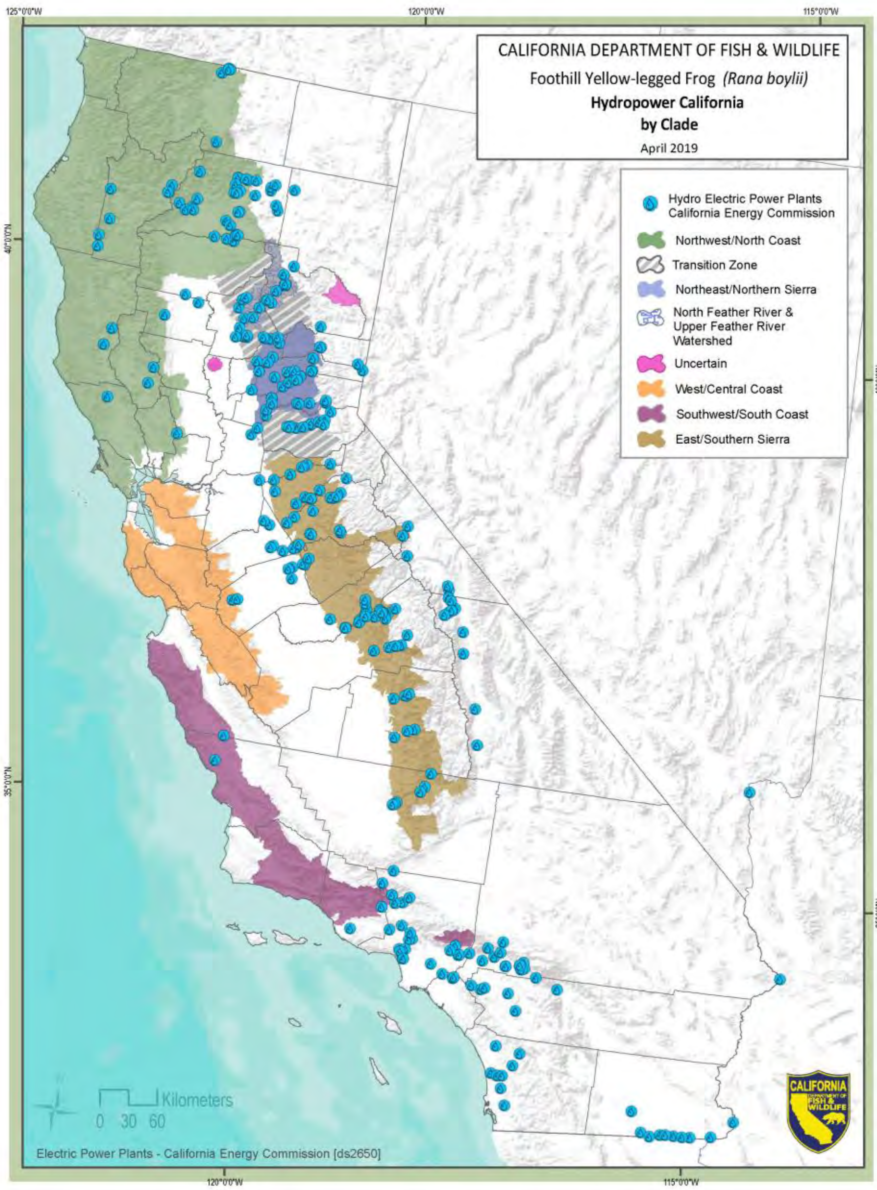

Figure 18. Locations of hydroelectric power generating dams (BIOS)

the Lewiston Dam on the Trinity River, habitat changes in a 63 km (39 mi) stretch from the dam downstream were evaluated (Lind et al. 1996). Riparian vegetation went from covering 30% of the riparian area pre-dam to 95% (Ibid.). Additionally, river bars made up 70% of the pre-dam riparian area compared to 4% post-dam, amounting to a 94% decrease in available Foothill Yellow-legged Frog breeding habitat (Ibid.).

Several features of riverine habitat below dams can decrease tadpole growth rate and other measures of fitness. As ectotherms, Foothill Yellow-legged Frogs require temperatures that support their metabolism, food conversion efficiency, growth, and development, and these temperatures may not be reached until late in the season, or not at all, when the water released is colder than their lower thermal limit (Kupferberg et al. 2011a, Catenazzi and Kupferberg 2013, Wheeler et al. 2014). Colder temperatures and higher flows reduce time spent feeding and efficiency at food assimilation, resulting in slower growth and development (Kupferberg et al. 2011a,b; Catenazzi and Kupferberg 2018). Large bed-scouring winter floods promote greater *Cladophora glomerate* blooms, the filamentous green alga that dominates primary producer biomass during the tadpole rearing season (Power et al. 2008, Kupferberg et al. 2011a). The period of most rapid tadpole growth often coincides with blooms of highly nutritious and more easily assimilated epiphytic diatoms, so reduced flows can have food-web impacts on tadpole growth and survival (Power et al. 2008, Kupferberg et al. 2011a, Catenazzi and Kupferberg 2018). In addition, colder temperatures and fluctuating summer flows, such as those released for hydroelectric power generation, can reduce the amount of algae available for grazing and can change the algal assemblage to one dominated by mucilaginous stalked diatoms like *Didymosphenia geminate* that have low nutritional value (Spring Rivers Ecological Sciences 2003, Kupferberg et al 2011a, Furey et al. 2014). Altered temperatures, flows, and food quality can contribute to slower growth and development, longer time to metamorphosis, smaller size at metamorphosis, and reduced body condition, which adversely impact fitness (Kupferberg et al. 2011b, Catenazzi and Kupferberg 2018).

As discussed in more detail in the Population Structure and Genetic Diversity section, both are strongly affected by river regulation (Peek 2011, 2018; Stillwater Sciences 2012). Foothill Yellow-legged Frogs primarily use watercourses as movement corridors, so the reservoirs created behind dams are often uninhabitable and represent barriers to gene flow (Bourque 2008; Peek 2011, 2018). This decreased connectivity can lead to loss of genetic diversity, ~~inducing~~ reducing a species' ability to adapt to changing conditions (Palstra and Ruzzante 2008).

Decreased winter discharge below dams facilitates establishment and expansion of invasive bullfrogs, whose tadpoles require overwintering and are not well-adapted to flooding events (Lind et al. 1996, Doubledee et al. 2003). Where they occur, bullfrogs tend to dominate areas more altered by dam operations than less impaired areas that support a higher proportion of native species (Moyle 1973, Fuller et al. 2011). In addition to downstream effects, the reservoirs created behind dams directly destroy lotic (flowing) Foothill Yellow-legged Frog habitat, typically do not retain natural riparian communities due to fluctuating water levels, are often managed for human activities not compatible with the species' needs, and act as a source of introduced species upstream and downstream (Brode and Bury 1984, PG&E 2018). Moyle and Randall (1998) identified characteristics of sites with low native biodiversity in the Sierra Nevada foothills; they were often drainages that had been dammed and

diverted in lower- to middle-elevations and dominated by introduced fishes and bullfrogs. Even small-scale operations can have significant effects. Some farming operations divert water during periods of high flows and store it in small impoundments for use during low flow-high need times; these ponds can serve as sources for introduced species like bullfrogs to spread into areas where the habitat would otherwise be unsuitable (Kupferberg 1996b).

The mechanisms described above result in the widespread pattern of greater Foothill Yellow-legged Frog density in unregulated rivers and in reaches far enough downstream of a dam to experience minimal effects from it (Lind et al. 1996, Kupferberg 1996a, Bobzien and DiDonato 2007, Peek 2011). Abundance in unregulated rivers averages five times greater than population abundance downstream of large dams (Kupferberg et al. 2012). Figure 19 depicts a comprehensive collection of egg mass density data where at least four years of surveys have been undertaken, showing much lower abundance in regulated rivers (S. Kupferberg pers. comm. 2019). In California, Foothill Yellow-legged Frog presence is associated with an absence of dams or with only small dams far upstream (Lind 2005, Kupferberg et al. 2012). Hydroelectric power generation from Sierra Nevada rivers accounts for nearly half its statewide production and about 9% of all electrical power used in California (Dettinger et al. 2018). Every major stream below 600 m (1968 ft) in the Sierra Nevada has at least one large reservoir (≥ 0.12 km^3 [100,000 ac-ft]), and many have multiple medium and small ones (Hayes et al. 2016). Because of this, Catenazzi and Kupferberg (2017) posit that the dam-effect on Foothill Yellow-legged Frog populations is likely greater in the Sierra Nevada than the Coast Range because dams are more often constructed in a series along a river in the former and spaced close enough together such that suitable breeding temperatures may never occur in the intervening reaches.

Pathogens and Parasites

Perhaps the most widely recognized amphibian disease is chytridiomycosis, which is caused by the fungal pathogen *Batrachochytrium dendroabatidis* (Bd). Implicated in the decline of over 500 amphibian species, including 90 presumed extinctions, it represents the greatest recorded loss of biodiversity attributable to a disease (Scheele et al. 2019). The global trade in American Bullfrogs (primarily for food) is connected to the disease's spread because the species can persist with low-level Bd infections without developing chytridiomycosis (Yap et al. 2018). Previous studies suggested Foothill Yellow-legged Frogs may not be susceptible to Bd-associated mass mortality; skin peptides strongly inhibited growth of the fungus in the lab, and the only detectable difference between Bd+ and Bd- juvenile Foothill Yellow-legged Frogs was slower growth (Davidson et al. 2007). At Pinnacles National Park in 2006, 18% of post-metamorphic Foothill Yellow-legged Frogs tested positive for Bd; all were asymptomatic and at least one Bd+ Foothill Yellow-legged Frog subsequently tested negative, demonstrating an ability to shed the fungus (Lowe 2009). However, recent studies have found historical evidence of Bd contributing to the extirpation of Foothill Yellow-legged Frogs in southern California, an acute die-off in 2013 in the Alameda Creek watershed, and another in 2018 in Coyote Creek (Adams et al. 2017a,b; Kupferberg and Catenazzi 2019). Evaluation of museum specimens indicates lower Bd prevalence (proportion of individuals infected) in Foothill Yellow-legged Frogs than most other co-occurring amphibians in southern California in the first part of the 20th century, but it spiked in the 1970s just prior to the last observation of an individual in 1977 (Adams et al. 2017b). Two museum specimens collected in 1966,

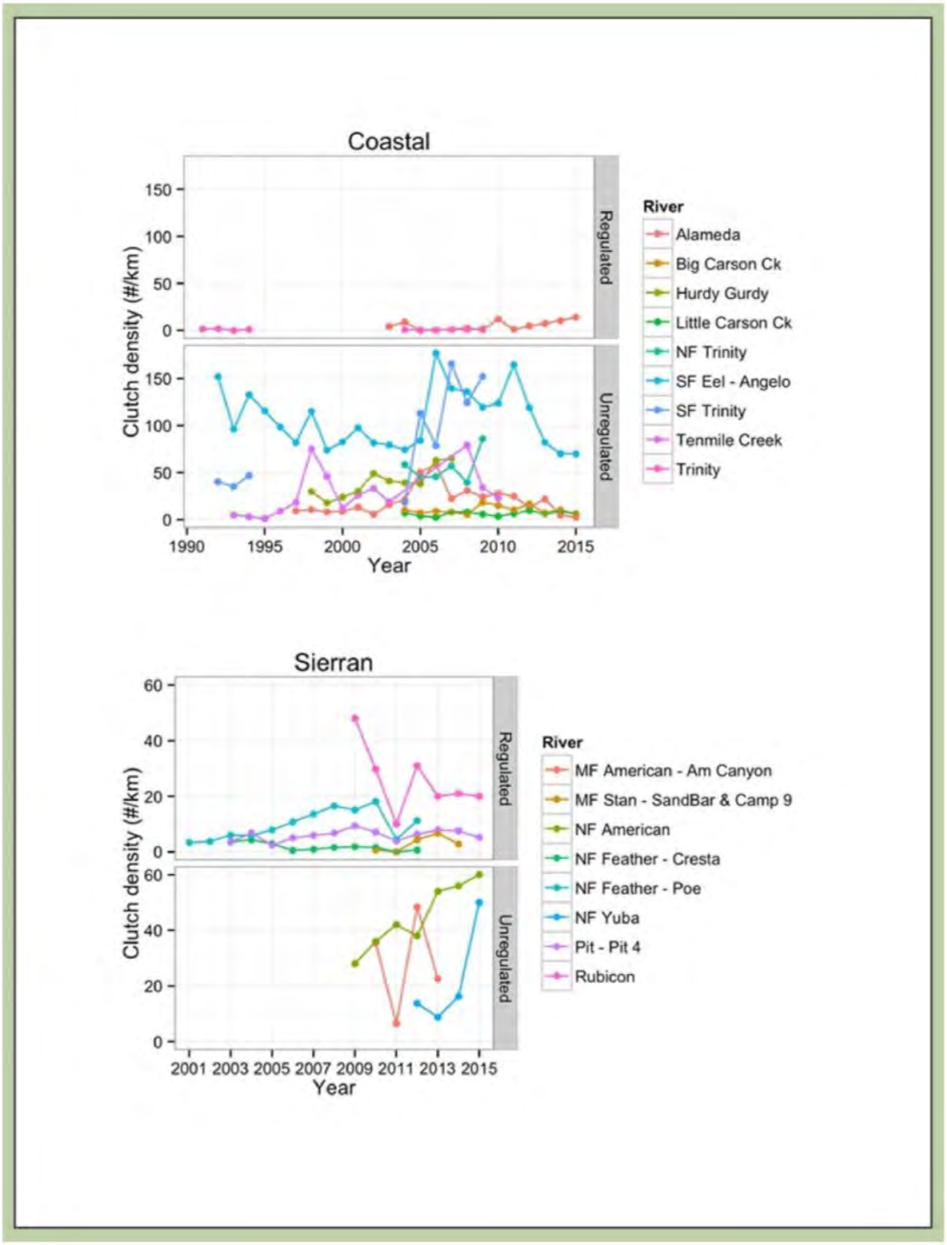

Figure 19. Foothill Yellow-legged Frog Egg mass density estimates along the coast from 1990-2015 and the Sierra Nevada from 2001-2015 from multiple studies compiled by S. Kupferberg (2019)

one from Santa Cruz County and the other from Alameda County, provide the earliest evidence of Bd in Foothill Yellow-legged Frogs in central California (Padgett-Flohr and Hopkins 2009). In contrast to the southern California results, Foothill Yellow-legged Frogs possessed the highest Bd prevalence among all amphibians tested in coastal Humboldt County in 2013 and 2014; however, zoospore (the aquatic dispersal agent) loads were well below the presumed lethal density threshold (Ecoclub Amphibian Group et al. 2016).

In addition to bullfrogs, the native Pacific Treefrog (~~*Pseudacris*~~ *Hyliola* ***regilla***) seems immune to the lethal effects of chytridiomycosis, and owing to its broad ecological tolerances, more terrestrial lifestyle, and relatively large home range size and dispersal ability, the species is ubiquitous across California (Padgett-Flohr and Hopkins 2009). In a laboratory experiment, Bd-infected Pacific Treefrogs shed an average of 68 zoospores per minute, making them the prime candidate for spreading and maintaining Bd in areas where bullfrogs do not occur (Padgett-Flohr and Hopkins 2009, Reeder et al. 2012). In the wild, Pacific Treefrog populations persisted at 100% of sites in the Sierra Nevada (above 1500 m [4920 ft]) where a sympatric ranid species had been extirpated from 72% of its formerly occupied sites due to a Bd outbreak (Reeder et al. 2012). This is consistent with the results of a model that incorporated Bd habitat suitability, host availability, and invasion history in North America, which concluded west coast mountain ranges were at the greatest risk from the disease (Yap et al. 2018).

Several other pathogens and parasites have been encountered with Foothill Yellow-legged Frogs, but none have been ascribed to large-scale mortality events. Another fungus, a water mold (*Saprolegnia* sp.) carried by fish, is an important factor in amphibian embryo mortality in the Pacific Northwest (Blaustein et al. 1994, Kiesecker and Blaustein 1997). Fungal infections of Foothill Yellow-legged Frog egg masses, potentially from *Saprolegnia*, have been observed in the mainstem Trinity River (Ashton et al. 1997). *Saprolegnia* infection is more likely to occur in ponds and lakes, particularly if stocked by hatchery-raised fish into previously fishless areas and when frogs use communal oviposition sites, so it likely does not represent a major source of mortality in Foothill Yellow-legged Frogs (Blaustein et al. 1994, Kiesecker and Blaustein 1997). However, they may be more susceptible to *Saprolegnia* infection when exposed to other environmental stressors that compromise their immune defenses (Blaustein et al. 1994, Kiesecker and Blaustein 1997).

The trematode parasite *Ribeiroia ondatrae* is responsible for limb malformations in ranids (Stopper et al. 2002). *Ribeiroia ondatrae* was detected on a single Foothill Yellow-legged Frog during a study on malformations, but its morphology was normal (Kupferberg et al. 2009a). The results of the study instead linked malformations in Foothill Yellow-legged Frog tadpoles and young-of-year to the Anchor Worm (*Lernae cyprinacea*), a parasitic copepod from Eurasia (Ibid.). Prevalence of malformations was low, under 4% of the population in both years of study, but there was a pattern of infected individuals metamorphosing at a smaller size, which as previously mentioned can have implications on fitness (Ibid.). Three other species of helminths (parasitic worms) were encountered during the study (*Echinostoma* sp., *Manodistomum* sp., and *Gyrodactylus* sp.); their relative impact on their hosts is unknown, but at least one Foothill Yellow-legged Frog had 700 echinstome cysts in its kidney (Ibid.). Bursey et al. (2010) discovered 13 species of helminths in and on Foothill Yellow-legged Frogs from

Humboldt County. Most are common in anurans, and some are generalists with multiple possible hosts, but studies on their impact on Foothill Yellow-legged Frogs are lacking (Ibid.).

Introduced Species

Species not native to an area, but introduced, can alter food webs and ecosystem processes through predation, competition, hybridization, disease transmission, and habitat modification. Native species lack evolutionary history with introduced species, and early life stages of native anurans are particularly susceptible to predation by aquatic non-native species (Kats and Ferrer 2003). Because introduced species often establish in highly modified habitats, it can be difficult to differentiate between impacts from habitat degradation and the introduced species (Fisher and Shaffer 1996). However, native amphibians have been frequently found successfully reproducing in heavily altered habitats when introduced species were absent, suggesting introduced species themselves can impose an appreciable adverse effect (Ibid.). Numerous introduced species have been documented to adversely impact Foothill Yellow-legged Frogs or are suspected of doing so.

American Bullfrogs were introduced to California from the eastern U.S. around the turn of the 20th century, likely in response to overharvest of native ranids by the frog-leg industry that accompanied the Gold Rush (Jennings and Hayes 1985). Nearly 50 years ago, Moyle (1973) reported that distributions of Foothill Yellow-legged Frogs and bullfrogs in the Sierra Nevada foothills were nearly mutually exclusive. He speculated that bullfrog predation and competition may be causal factors in their disparate distributions in addition to the habitat degradation from dams and diversions that facilitated the bullfrog invasion in the first place. In a study along the South Fork Eel River and one of its tributaries, Foothill Yellow-legged Frog abundance was nearly an order of magnitude lower in reaches were bullfrogs were well established (Kupferberg 1997a). At a site in Napa Valley, after bullfrogs were eradicated, Foothill Yellow-legged Frogs, among other native species, recolonized the area (J. Alvarez pers. comm. 2018). In a mesocosm experiment, Foothill Yellow-legged Frog survival in control enclosures measured half that of enclosures containing bullfrog and Foothill Yellow-legged Frog tadpoles, and they weighed approximately one-quarter lighter at metamorphosis (Kupferberg 1997a). The mechanism for these declines appeared to be the reduction of high quality algae by bullfrog tadpole grazing, as opposed to any behavioral or chemical interference (Ibid.). Adult bullfrogs, which can get very large (9.0-15.2 cm [3.5-6.0 in]), also directly consume Foothill Yellow-legged Frogs, including adults (Moyle 1973, Crayon 1998, Powell et al. 2016). Silver (2017) noted that she never heard Foothill Yellow-legged Frogs calling in areas with bullfrogs, which has implications for breeding success; she speculated the lack of vocalizations may have been a predator avoidance strategy.

As discussed briefly in the Pathogens and Parasites section, American Bullfrogs act as reservoirs and vectors of the lethal chytrid fungus. In museum specimens from both southern and central California, Bd was detected in bullfrogs before it was detected in Foothill Yellow-legged Frogs in the same area (Padgett-Flohr and Hopkins 2009, Adams et al. 2017b). During a die-off from chytridiomycosis that commenced in 2013, Bd prevalence and load in Foothill Yellow-legged Frogs was positively predicted by bullfrog presence (Adams et al. 2017a). A similar die-off in 2018 from a nearby county appears to be related to transmission by bullfrogs as well (Kupferberg and Catenazzi 2019). In addition, male Foothill

Yellow-legged Frogs have been observed amplexing female bullfrogs, which may not only constitute wasted reproductive effort but could serve to increase their likelihood of contracting Bd (Lind et al. 2003a). In fact, adult males were more likely to be infected with Bd than females or juveniles during the recent die-off in Alameda Creek (Adams et al. 2017a). African Clawed Frogs (*Xenopus laevis*) have also been implicated in the spread of Bd in California because like bullfrogs, they are asymptomatic carriers (Padgett-Flohr and Hopkins 2009). However, African Clawed-Frog distribution only minimally overlaps with the Foothill Yellow-legged Frog's range unlike the widespread bullfrog (Stebbins and McGuinness 2012).

Hayes and Jennings (1986) observed a negative association between the abundance of introduced fish and Foothill Yellow-legged Frogs. Rainbow trout (*Onchorynchus mykiss*) and green sunfish (*Lepomis cyanellus*) are suspected of destroying egg masses (Van Wagner 1996). Bluegill sunfishes (*L. macrochirus*) are likely predators; in captivity when offered eggs and tadpoles of two ranid species, they consumed both life stages but a significantly greater number of tadpoles (Werschkul and Christensen 1977). Common hatchery-stocked fish like brook (*Salvelinus fontinalis*) and rainbow trout commonly carry of *Saprolegnia* (Blaustein et al. 1994). In addition, presence of non-native fish can facilitate bullfrog invasions by reducing the density of macroinvertebrates that prey on their tadpoles (Adams et al. 2003). Foothill Yellow-legged Frog tadpoles raised from eggs from sites with and without smallmouth bass (*Micropterus dolomieu*) did not differ in their responses to exposure to the non-native, predatory bass and a native, non-predatory fish (Paoletti et al. 2011). This result suggests that Foothill Yellow-legged Frogs have not yet evolved a recognition of bass as a threat, which makes them more vulnerable to predation (Ibid.).

Introduced into several areas within the Coast Range and Sierra Nevada, signal crayfish have been recorded preying on Foothill Yellow-legged Frog egg masses and are suspected of preying on their tadpoles based on observations of tail injuries that looked like scissor snips (Riegel 1959, Wiseman et al. 2005). The introduced red swamp crayfish (*Procambarus clarkii*) likely also preys on Foothill Yellow-legged Frogs. Because Foothill Yellow-legged Frogs evolved with native crayfish in northern California, individuals from those areas may more effectively avoid crayfish predation than in other parts of the state where they are not native (Riegel 1959, USFWS 1998, Kats and Ferrer 2003). The Foothill Yellow-legged Frog's naivety to crayfish was demonstrated in a study that showed they did not change behavior when exposed to signal crayfish chemical cues, but once the crayfish was released and consuming Foothill Yellow-legged Frog tadpoles, the survivors, likely reacting to chemical cues from dead tadpoles, did respond (Kerby and Sih 2015).

Sedimentation

Several anthropogenic activities, some of which are described in greater detail below, can artificially increase sedimentation into waterways occupied by Foothill Yellow-legged Frogs and adversely impact biodiversity (Moyle and Randall 1998). These activities include but are not limited to mining, agriculture, overgrazing, timber harvest, and poorly constructed roads (Ibid.). Increased fine sediments can substantially degrade Foothill Yellow-legged Frog habitat quality. Heightened turbidity decreases light penetration that phytoplankton and other aquatic plants require for photosynthesis (Cordone and Kelley

1961). When silt particles fall out of the water column, they can destroy algae by covering the bottom of the stream (Ibid.). Algae are not only important for Foothill Yellow-legged Frog tadpoles as forage but also oxygen production (Ibid.). Sedimentation may impede attachment of egg masses to substrate (Ashton et al. 1997). The effect of silt accumulation on embryonic development is unknown, but it does make them less visible, which could decrease predation risk (Fellers 2005). Fine sediments can fill interstitial spaces between rocks that tadpoles use for shelter from high velocity flows and cover from predators and that serve as sources for aquatic invertebrate prey for post-metamorphic Foothill Yellow-legged Frogs (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b).

Mining

Current mining practices, as well as legacy effects from historical mining operations, may adversely impact Foothill Yellow-legged Frogs through contaminants, direct mortality, habitat destruction and degradation, and behavioral disruption. While mercury in streams can result from atmospheric deposition, storm-induced runoff of naturally occurring mercury, agricultural runoff, and geothermal springs, runoff from historical mine sites mobilizes a significant amount of mercury (Foe and Croyle 1998, Alpers et al. 2005, Hothem et al. 2010). Beginning in the mid-1800s, extensive mining occurred in the Coast Range to supply mercury for gold mining in the Sierra Nevada, causing widespread contamination of both mountain ranges and the rivers in the Central Valley (Foe and Croyle 1998). Studies on Foothill Yellow-legged Frog tissues collected from the Cache Creek (Coast Ranges) and Greenhorn Creek (Sierra Nevada) watersheds revealed mercury bioaccumulation concentrations as high as 1.7 and 0.3 µg/g (ppm), respectively (Alpers et al. 2005, Hothem et al. 2010). For context, the U.S. Environmental Protection Agency's mercury criterion for issuance of health advisories for fish consumption is 0.3 µg/g; concentrations exceeded this threshold in Foothill Yellow-legged Frog tissues at 62% of sampling sites in the Cache Creek watershed (Hothem et al. 2010). Bioaccumulation of this powerful neurotoxin can cause deleterious impacts on amphibians including inhibited growth, decreased survival to metamorphosis, increased malformations, impaired reproduction, and other sublethal effects (Zillioux et al. 1993, Unrine et al. 2004). In a study measuring Sierra Nevada watershed health, Moyle and Randall (1998) reportedly found very low biodiversity in streams that were heavily polluted by acidic water leaching from historical mines. Acidic drainage measured as low as pH 3.4 ~~pH~~ from some mined areas in the northern Sierra Nevada (Alpers et al. 2005).

Widespread suction dredging for gold occurred in the Foothill Yellow-legged Frog's California range until enactment of a moratorium on issuing permits in 2009 (Hayes et al. 2016). Suction dredging vacuums up the contents of the streambed, passes them through a sluice box to separate the gold, and then deposits the tailings on the other side of the box (Harvey and Lisle 1998). While most habitat disturbance is localized and minor, it can be especially detrimental if it degrades or destroys breeding and rearing habitat through direct disturbance or sedimentation (Ibid.). In addition, this activity can lead to direct mortality of early life stages through entrainment, and those eggs and tadpoles that do survive passing through the suction dredge may experience greater mortality due to subsequent unfavorable physiochemical conditions and possible increased predation risk (Ibid.). Suction dredging can also reduce the availability of invertebrate prey, although this impact is typically short-lived (Ibid.). Suction dredging alters stream morphology, and relict tailing ponds can serve as breeding habitat for bullfrogs in areas

that would not normally support them (Fuller et al. 2011). However, in some areas these mining holes have reportedly benefited Foothill Yellow-legged Frogs by creating cool persistent pools that adult females appeared to prefer at one Sierra Nevada site (Van Wagner 1996). Senate Bill 637 (2015) directs the Department to work with the State Water Resources Control Board (SWRCB) to develop a statewide water quality permit that would authorize the use of vacuum or suction dredge equipment in California under conditions set forth by the two agencies. SWRCB staff, in coordination with Department staff, are in the process of collecting additional information to inform the next steps that will be taken by the SWRCB (SWRCB 2019).

Instream aggregate (gravel) mining continues today and can have similar impacts to suction dredge mining by removing, processing, and relocating stream substrates (Olson and Davis 2009). This type of mining typically removes bars used as Foothill Yellow-legged Frog breeding habitat and reduces habitat heterogeneity by creating flat wide channels (Kupferberg 1996a). Typically when listed salmonids are present, mining must be conducted above the wetted edge, but this practice can create perennial off-channel bullfrog breeding ponds (M. van Hattem pers. comm. 2018).

Agriculture

Direct loss of Foothill Yellow-legged Frog habitat from wildland conversion to agriculture is rare because the typically rocky riparian areas they inhabit are usually not conducive to farming, but removal of riparian vegetation directly adjacent to streams for agriculture is more common and widespread. The U.S. Department of Agriculture classifies 3.9 million ha (9.6 million ac) in California as cropland, which amounts to less than 10% of the state's land area, and 70% of this occurs in the Central Valley between Redding and Bakersfield (Martin et al. 2018). In addition, several indirect impacts can adversely affect Foothill Yellow-legged Frogs at substantial distances from agricultural operations such as effects from runoff (sediments and agrochemicals), drift and deposition of airborne pollutants, water diversions, and creation of novel habitats like impoundments that facilitate spread of detrimental non-native species. As sedimentation and introduced species impacts were previously discussed, this section instead focuses on the other possible adverse impacts.

Agrochemicals

Many species of amphibians, particularly ranids, have experienced declines throughout California, but the most dramatic declines have occurred in the Sierra Nevada east of the San Joaquin Valley where 60% of the total pesticide usage in the state was sprayed (Sparling et al. 2001). Agrochemicals applied to crops in the Central Valley can volatilize and travel in the atmosphere and deposit in higher elevations (LeNoir et al. 1999). Pesticide concentrations diminish as elevations increase in the lower foothills but change little from 533 to 1,920 m (1,750-6,300 ft), which coincides with the Foothill Yellow-legged Frog's elevational range (Ibid). Foothill Yellow-legged Frog absence at historically occupied sites in California significantly correlated with agricultural land use within 5 km (3 mi), and a positive relationship exists between Foothill Yellow-legged Frog declines and the amount of upwind agriculture, suggesting airborne agrochemicals may be a contributing factor (Figure 20; Davidson et al. 2002). Cholinesterase-inhibitors (most organophosphates and carbamates), which disrupt nerve impulse transmission, were

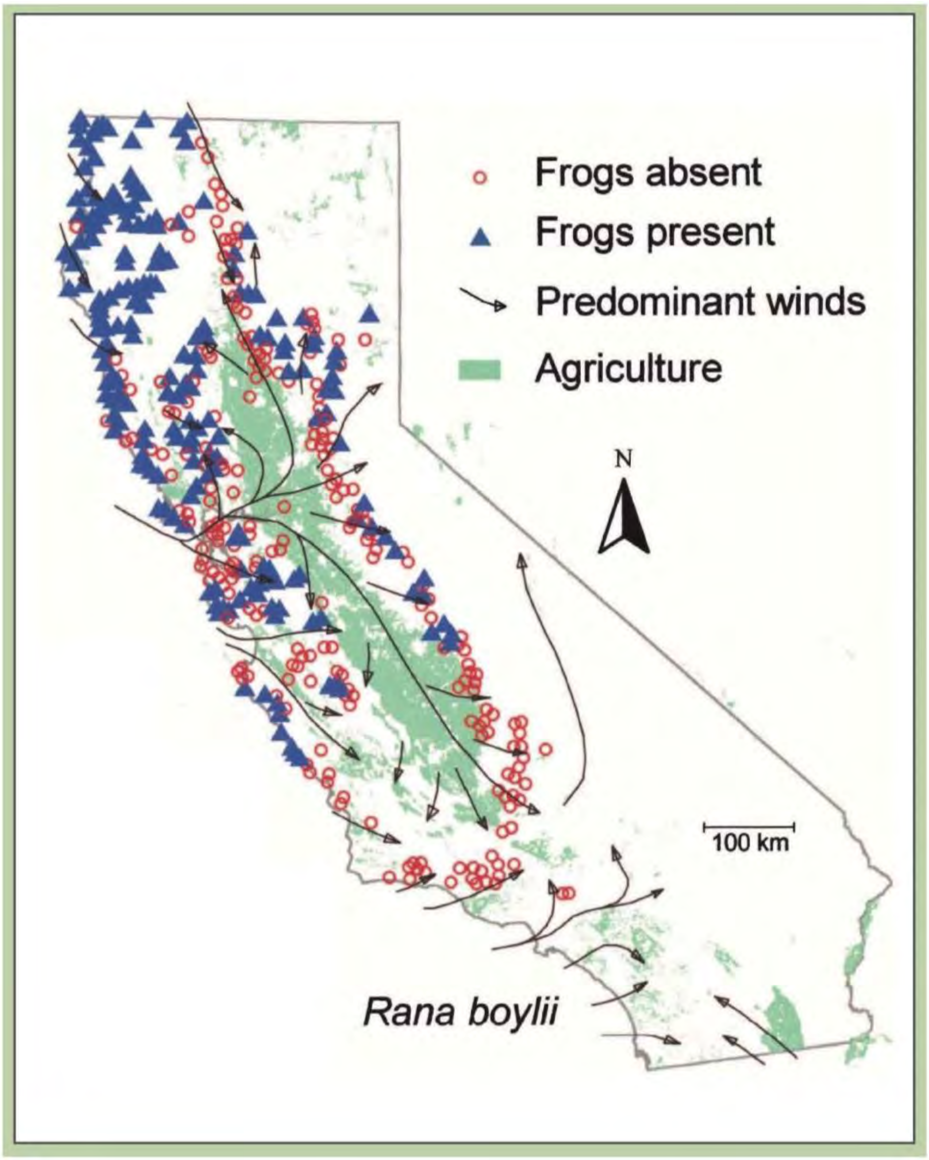

Figure 20. Relationship of Foothill Yellow-legged Frog occupancy to agriculture from Davidson et al. (2002)

more strongly associated with population declines than other pesticide types (Davidson 2004). Olson and Davis (2009) and Lind (2005) also reported a negative correlation between Foothill Yellow-legged Frog presence and proximity and quantity of nearby agriculture in Oregon and across the species' entire range, respectively.

Lethal and sublethal effects of agrochemicals on amphibians can take two general forms: direct toxicity and food-web effects. Sublethal doses of agrochemicals can interact with other environmental stressors to reduce fitness. Foothill Yellow-legged Frog tadpoles showed significantly greater vulnerability to the lethal and sublethal effects of carbaryl than Pacific Treefrogs (Kerby and Sih 2015). An inverse relationship exists between carbaryl concentration and Foothill Yellow-legged Frog activity, and their 72-h LC_{50} (concentration at which 50% die) measured one-fifth that of Pacific Treefrogs (Ibid.). Carbaryl slightly decreased Foothill Yellow-legged Frog development rate, but it significantly increased susceptibility to predation by signal crayfish despite nearly no mortality in the pesticide- and predator-only treatments (Ibid.). Sparling and Fellers (2009) also found Foothill Yellow-legged Frogs were significantly more sensitive to pesticides (chlorpyrifos and endosulfan in this study) than Pacific Treefrogs; their 96-hr LC_{50} was nearly five-times less than for treefrogs. Endosulfan was nearly 121 times more toxic to Foothill Yellow-legged Frogs than chlorpyrifos, and water samples from the Sierra Nevada have contained endosulfan concentrations within their lethal range and sometimes greater than the LC_{50} for the species (Ibid.). Sublethal effects included smaller body size, slower development rate, and increased time to metamorphosis (Ibid.). Sparling and Fellers (2007) determined the organophospates chlorpyrifos, malathion, and diazinon can harm Foothill Yellow-legged Frog populations, and their oxon derivatives (the resultant compounds once they begin breaking down in the body) were 10 to 100 times more toxic than their respective parental forms.

Extrapolating the results of studies on other ranids to Foothill Yellow-legged Frogs should be undertaken with caution; however, those studies can demonstrate additional potential adverse impacts of exposure to agrochemicals. Relyea (2005) discovered that Roundup®, a common herbicide, could cause rapid and widespread mortality in amphibian tadpoles via direct toxicity, and overspray at the manufacturer's recommended application concentrations would be highly lethal. Atrazine, another common herbicide, has been implicated in disrupting reproductive processes in male Northern Leopard Frogs (*Rana pipiens*) by slowing gonadal development, inducing hermaphroditism, and even oocyte (egg) growth (Hayes et al. 2003). However, recent research on sex reversal in wild populations of Green Frogs (*R. clamitans*) suggests it may be a relatively common natural process unrelated to environmental contaminants, requiring more research (Lambert et al. 2019). Malathion, a common organophosphate insecticide, that rapidly breaks down in the environment, applied at low concentrations caused a trophic cascade that resulted in reduced growth and survival of two species of ranid tadpoles (Relyea and Diecks 2008). Malathion caused a reduction in the amount of zooplankton, which resulted in a bloom of phytoplankton and an eventual decline in periphyton, an important food source for tadpoles (Ibid.). In contrast, Relyea (2005) found that some insecticides increased amphibian tadpole survival by reducing their invertebrate predators. Runoff from agricultural areas can contain fertilizers that input nutrients into streams and increase productivity, but they can also result in harmful algal blooms (Cordone and

Kelley 1961). In addition, exposure to pesticides can result in immunosuppression and reduce resistance to the parasites that cause limb malformations (Kiesecker 2002, Hayes et al. 2006).

Cannabis

An estimated 60-70% of the cannabis (*Cannabis indica* and *C. sativa*) used in the U.S. from legal and illegal sources is grown in California, and most comes from the Emerald Triangle, an area comprised of Humboldt, Mendocino, and Trinity counties (Ferguson 2019). Small-scale illegal cannabis farms have operated in this area since at least the 1960s but have expanded rapidly, particularly trespass grows on public land primarily by Mexican cartels, since the passage of the Compassionate Use Act in 1996 (Mallery 2010, Bauer et al. 2015). Like other forms of agriculture, it involves clearing the land, diverting water, and using herbicides and pesticides; however, in addition, many of these illicit operations use large quantities of fertilizers and highly toxic banned pesticides to kill anything that may threaten the crop, and they leave substantial amounts of non-biodegradable trash and human excrement (Mallery 2010, Thompson et al. 2014, Carah et al. 2015).

Measurements of environmental impacts of illegal cannabis grows have been hindered by the difficult and dangerous nature of accessing many of these sites; however, some analyses have been conducted, often using aerial images and geographic information systems (GIS). An evaluation of 54% of watersheds within and bordering Humboldt County revealed that while cannabis grow sites are generally small (< 0.5 ha [1.2 ac]) and comprised a tiny fraction of the study area (122 ha [301 ac]), they were widespread (present in 83% of watersheds) but unevenly distributed, indicating impacts are concentrated in certain watersheds (Butsic and Brenner 2016, Wang et al. 2017). The results also showed that 68% of grows were > 500 m (0.3 mi) from developed roads, 23% were located on slopes steeper than 30%, and 5% were within 100 m (328 ft) of critical habitat for threatened salmonids (Butsic and Brenner 2016). These characteristics suggest wildlands adjacent to cannabis cultivations are at heightened risk of habitat fragmentation, erosion, sedimentation, landslides, and impacts to waterways critical to imperiled species (Ibid.).

A separate analysis in the same general area estimated potentially significant impacts from water diversions alone. Cannabis requires a substantial amount of water during the growing season, so it is often cultivated near sources of perennial surface water for irrigation, commonly diverting from springs and headwater streams (Bauer et al. 2015). In the least impacted of the study watersheds, Bauer et al. (2015) calculated that diversions for cannabis cultivation could reduce the annual seven-day low flow by up to 23%, and in some of the heavily impacted watersheds, water demands for cannabis could exceed surface water availability. If not regulated carefully, cannabis cultivation could have substantial impacts on sensitive aquatic species like Foothill Yellow-legged Frogs in watersheds in which it is concentrated.

For context, cannabis cultivation was responsible for approximately 1.1% of forest cover lost within study watersheds in Humboldt County from 2000 to 2013, while timber harvest accounted for 53.3% (Wang et al. 2017). Cannabis requires approximately two times as much water per day as wine grapes, the other major irrigated crop in the region (Bauer et al. 2015). Impacts from cannabis cultivation have been observed by Foothill Yellow-legged Frog researchers working on the Trinity River and South Fork

Eel River in the form of lower flows in summer, increased egg stranding, and more algae earlier in the season in recent years (S. Kupferberg and M. Power pers. comm. 2015; D. Ashton pers. comm. 2017; S. Kupferberg, M. van Hattem, and W. Stokes pers. comm. 2017). In addition, Gonsolin (2010) reported illegal cannabis cultivations on four headwater streams that drained into his study area along Coyote Creek, three of which were occupied by Foothill Yellow-legged Frogs. The cultivators had removed vegetation adjacent to the creeks, terraced the slopes, diverted water, constructed small water impoundments, poured fertilizers directly into the impoundments, and applied herbicides and pesticides, as evidenced by leftover empty containers littering the site.

Commercial sale of cannabis for recreational use became legal in California on January 1, 2018, through passage of the Control, Regulate and Tax Adult Use of Marijuana Act (2016), and with it an environmental permitting system and habitat restoration fund was established. The number of applications for temporary licenses per watershed is depicted in Figure 21. Two of the expected outcomes of passage of this law were that the profit-margin on growing cannabis would fall to the point that it would discourage illegal trespass grows and move the bulk of the cultivation out of remote forested areas into existing agricultural areas like the Central Valley (CSOS 2016). However, until cannabis is legalized at the federal level, these results may not occur since banks are reluctant to work with growers due to federal prohibitions subjecting them to prosecution for money laundering (ABA 2019). Additional details on cannabis permitting at the state level can be found under the Existing Management section.

Vineyards

Vineyard operators historically built on-stream dams and removed almost all the riparian vegetation to make room for vines and for ease of irrigation (M. van Hattem pers. comm. 2019). They still divert a substantial amount of water for irrigation, and they build on- and off-stream impoundments that support bullfrogs (Ibid.). The acreage of land planted in wine grapes in California began rising dramatically in the 1970s and now accounts for 90% of wine produced in the U.S. (Geisseler and Horwath 2016, Alston et al. 2018). The number of wineries in California rose from approximately 330 to nearly 2,500 between 1975 and 2006; however, expansion slowed and has reversed slightly recently with 24,300 ha (60,000 ac), or 6.5% of total area planted, removed between 2015 and 2017 (Volpe et al. 2010, CDFA 2018). In 2015, 347,000 ha (857,000 ac) were planted in grapes with 70% located in the San Joaquin Valley; 66%, 21%, and 13% were planted in wine, raisin, and table grapes, respectively (Alston et al. 2018).

Expansion of wineries in the coastal counties converted natural areas such as oak woodlands and forests to vineyards (Merenlender 2000, Napa County 2010). The area of Sonoma County covered in grapes increased by 32% from 1990 to 1997, and 42% of these new vineyards were planted above 100 m (328 ft) with 25% on slopes greater than 18% (Merelender 2000). For context, only 18% of vineyards planted before 1990 occurred above 100 m (328 ft) and less than 6% on slopes greater than 18% (Ibid.). This conversion took place on approximately 773 ha (1,909 ac) of conifer and dense hardwood forest, 149 ha (367 ac) of shrubland, and 2,925 ha (7,229 ac) of oak grassland savanna (Ibid.).

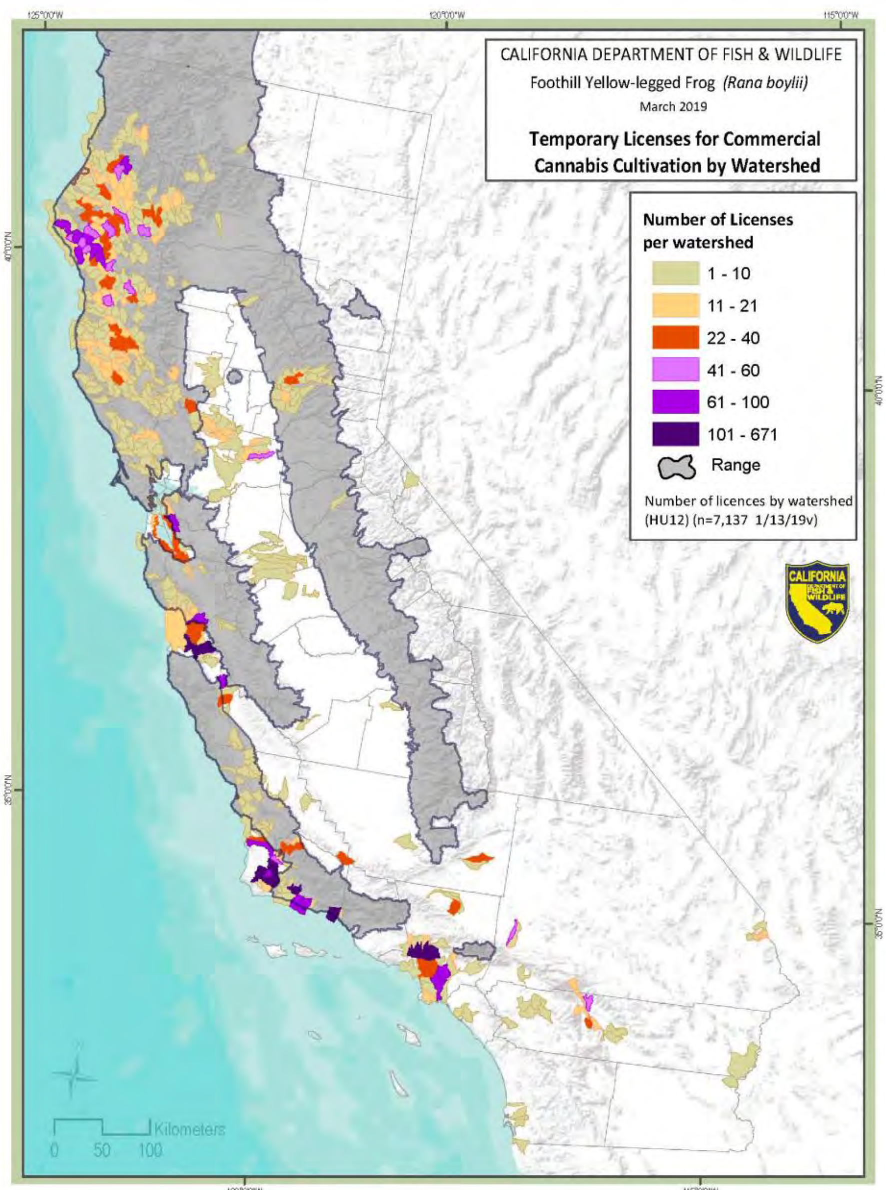

Figure 21. Cannabis cultivation temporary licenses by watershed in California (CDFA, NHD)

Recent expansion of oak woodland conversion to vineyards in Napa County was highest in its eastern hillsides (Napa County 2010). The County estimates that 1,085 and 1,240 ha (2,682-3,065 ac) of woodlands will be converted to vineyards between 2005 and 2030 (Ibid.). For context, 297 ha (733 ac) were converted from 1992 to 2003 (Ibid.). In addition, wine grapes were second only to almonds in terms of overall quantity of pesticides applied in California in 2016, but the quantity per unit area (2.9 kg/ha [2.6 lb/ac]) was 160% greater for the wine grapes (CDPR 2018). Vineyard expansion into hillsides has continued into sensitive headwater areas, and like cannabis cultivation, even small vineyards can have substantial impacts on Foothill Yellow-legged Frog habitat through sedimentation, water diversions, spread of harmful non-native species, and pesticide contamination (Merelender 2000, K. Weiss pers. comm. 2018).

Livestock Grazing

Livestock grazing can be an effective habitat management tool, including control of riparian vegetation encroachment, but overgrazing can significantly degrade the environment (Siekert et al. 1985). Cattle display a strong preference for riparian areas and have been implicated as a major source of habitat damage in the western U.S. where the adverse impacts of overgrazing on riparian vegetation are intensified by arid and semi-arid climates (Behnke and Raleigh 1978, Kauffman and Krueger 1984, Belsky et al. 1999). The severity of grazing impacts on riparian systems can be influenced by the number of animals, duration and time of year, substrate composition, and soil moisture (Benhke and Raleigh 1978, Kauffman et al. 1983, Marlow and Pogacnik 1985, Siekert et al. 1985). In addition to habitat damage, cattle can directly trample any life stage of Foothill Yellow-legged Frog.

Signs of overgrazing include impacts to the streambanks such as increased slough-offs and cave-ins that collapse undercuts used as refuge (Kauffman et al. 1983). Overgrazing reduces riparian cover, increases erosion and sedimentation, which as described above can result in silt degradation of breeding, rearing, and invertebrate food-producing areas (Cordone and Kelley 1961, Behnke and Raleigh 1978, Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). Loss of streamside and instream vegetative cover and changes to channel morphology can increase water temperatures and velocities (Behnke and Raleigh 1978). Water quality can be affected by increased turbidity and nutrient input from excrement, and seasonal water quantity can be impacted through changes to channel morphology (Belsky et al. 1999). In addition, increased nutrients and temperatures can promote blooms of harmful cyanobacteria like *Microcystis aeruginosa*, which releases a toxin when it expires that can cause liver damage to amphibians as well as other animals including humans (Bobzien and DiDonato 2007, Zhang et al. 2013).

While some recent studies indicate livestock grazing continues to damage stream and riparian ecosystems, its impact on Foothill Yellow-legged Frogs in California is unknown (Belsky et al. 1999, Hayes et al. 2016). In Oregon, the species' presence was correlated with significantly less grazing than where they were absent according to Borisenko and Hayes's 1999 report (as cited in Olson and Davis 2009). However, Fellers (2005) reported that apparently some Coast Range foothill populations occupying streams draining east into the San Joaquin Valley were doing well at the time of publication despite being heavily grazed.

Urbanization and Road Effects

Habitat conversion and fragmentation combined with modified environmental disturbance regimes can substantially jeopardize biological diversity (Tracey et al. 2018). This threat is most severe in areas like California with Mediterranean-type ecosystems that are biodiversity hot spots, fire-prone, and heavily altered by human land use (Ibid.). From 1990 to 2010, the fastest-growing land use type in the conterminous U.S. was new housing construction, which rapidly expanded the wildland-urban interface (WUI) where houses and natural vegetation meet or intermix on the landscape (Radeloff et al. 2018).

Of several variables tested, proportion of urban land use within a 5 km (3.1 mi) radius of a site was associated with Foothill Yellow-legged Frog declines (Davidson et al. 2002). Lind (2005) also found significantly less urban development nearby and upwind of sites occupied by Foothill Yellow-legged Frogs, suggesting pollutant drift may be a contributing factor. Changes in wildfires may also contribute to the species' declines; 95% of California's fires are human-caused, and wildfire issues are greatest at the WUI (Syphard et al. 2009, Radeloff et al. 2018). Population density, intermix WUI (where wildland and development intermingle as opposed to an abrupt interface), and distance to WUI explained the most variability in fire frequency (Syphard et al. 2007). In addition to wildfires, habitat loss, and fragmentation, urbanization can impact adjacent ecosystems through non-native species introduction, native predator subsidization, and disease transmission (Bar-Massada et al. 2014).

Projections show growth in California's population to 51 million people by 2060 from approximately 40 million currently (PPIC 2019). This will increase urbanization, the WUI, and habitat fragmentation. The Department of Finance projects the Inland Empire, the San Joaquin Valley, and the Sacramento metropolitan area will be the fastest-growing regions of the state over the next several decades (Ibid.). This puts the greatest pressure in areas outside of the Foothill Yellow-legged Frog's range; however, because the environmental stressors associated with urbanization can span far beyond its physical footprint, they may still adversely affect the species.

Highways are frequently recognized as barriers to dispersal that fragment habitats and populations; however, single-lane roads can pose significant risks to wildlife as well (Cook et al. 2012, Brehme et al. 2018). Foothill Yellow-legged Frogs are at risk of being killed by vehicles when roads are located near their habitat (Cook et al. 2012, Brehme et al. 2018). Fifty-six juvenile Foothill Yellow-legged Frogs were found on a road adjacent to Sulphur Creek (Mendocino County), seven of which had been struck and killed (Cook et al. 2012). When fords (naturally shallow areas) are used as vehicle crossings, they can create sedimentation and poor water quality, and in some cases, the fords are gravel or cobble bars used by Foothill Yellow-legged Frogs for breeding that could result in direct mortality (K. Blanchard pers. comm. 2018, R. Bourque pers. comm. 2018). Construction of culverts under roads to keep vehicles out of the streambed can result in varying impacts. In some cases, they can impede dispersal and create deep scoured pools that support predatory fish and frogs, but when properly constructed, they can facilitate frog movement up and down the channel with reduced road mortality (Van Wagner 1996, GANDA 2008). In areas where non-native species are not a threat, but premature drying is, pools created by culverts can provide habitat in otherwise unsuitable areas (M. Grefsrud pers. comm. 2019). An evaluation of the impact of roads on 166 native California amphibians and reptiles through direct

morality and barriers to movement concluded that Foothill Yellow-legged Frogs, at individual and population levels, were at moderate risk of road impacts in aquatic habitat but very low risk of impacts in terrestrial habitat (Brehme et al. 2018). For context, all chelonids (turtles and tortoises), 72% of snakes, 50% of anurans, 18% of lizards, and 17% of salamander species in California were ranked as having a high or very high risk of negative road impacts in the same evaluation (Ibid.).

Poorly constructed roadways near rivers and streams can result in substantial erosion and sedimentation, leading to reduced amphibian densities (Welsh and Ollivier 1998). Proximity of roads to Foothill Yellow-legged Frog habitat contributes to petrochemical runoff and poses the threat of spills (Ashton et al. 1997). A diesel spill on Hayfork Creek (Trinity County) resulted in mass mortality of Foothill Yellow-legged Frog tadpoles and partial metamorphs (Bury 1972). Roads have also been implicated in the spread of disease and may have aided in the spread of Bd in California (Adams et al. 2017b).

Frogs use auditory and visual cues to defend territories and attract mates, and some studies reveal that realistic levels of traffic noise can impede transmission and reception of these signals (Bee and Swanson 2007). Some male frogs have been observed changing the frequency of their calls to increase the distance they can be heard over traffic noise, but if females have evolved to recognize lower pitched calls as signs of superior fitness, this potential trade-off between audibility and attractiveness could have implications for reproductive success (Parris et al. 2009). In a separate study, traffic noise caused a change in male vocal sac coloration and an increase in stress hormones, which changed sexual selection processes and suppressed immunity (Troïanowski et al. 2017). Because Foothill Yellow-legged Frogs mostly call underwater and are not known to use color displays, communication cues may not be adversely affected by traffic noise, but their stress response is unknown.

Timber Harvest

Because Foothill Yellow-legged Frogs tend to remain close to the water channel (i.e., within the riparian corridor) and current timber harvest practices minimize disturbance in riparian areas for the most part, adverse effects from timber harvest are expected to be relatively low (Hayes et al. 2016, CDFW 2018b). However, some activities have a potential to negatively impact Foothill Yellow-legged Frogs or their habitat, including direct mortality and increased sedimentation during construction and decommissioning of watercourse crossings and infiltration galleries, tree felling, log hauling, and entrainment by water intakes or desiccation of eggs and tadpoles through stranding from dewatering during drafting operations (CDFW 2018b,c). In addition to impacts previously described under the Sedimentation and Road Effects section, when silt runoff into streams is accompanied by organic materials, such as logging debris, impaired water quality can result, including reduced dissolved oxygen, which is important in embryonic and tadpole development (Cordone and Kelley 1961).

Because Foothill Yellow-legged Frogs are heliotherms (i.e, they bask in the sun to raise their body temperature) and sensitive to thermal extremes, some moderate timber harvest may benefit the species (Zweifel 1955, Fellers 2005). Ashton (2002) reported 85% of his Foothill Yellow-legged Frog observations occurred in second-growth forests (37-60 years post-harvest) as opposed to late-seral forests and postulated that the availability of some open canopy areas played a major part in this

disparity. Foothill Yellow-legged Frogs are typically absent in areas with closed canopy (Welsh and Hodgson 2011). Reduced canopy also raises stream temperatures, which could improve tadpole development and promote algal and invertebrate productivity in otherwise cold streams (Olson and Davis 2009; Catenazzi and Kupferberg 2013,2017).

Recreation

Several types of recreation can adversely impact Foothill Yellow-legged Frogs, and some are more severe and widespread than others. One of the main potential factors identified by herpetologists as contributing to disappearance of Foothill Yellow-legged Frogs in southern California was increased and intensified recreation in streams (Adams et al. 2017b). The greater number of people traveling into the backcountry may have facilitated the spread Bd to these areas, and while no evidence shows stress from disturbance or other environmental pressures increases susceptibility to Bd, the stress hormone corticosterone has been implicated in immunosuppression (Hayes et al. 2003, Adams et al. 2017b).

The amount of Foothill Yellow-legged Frog habitat disturbed by off-highway motor vehicles (OHV) throughout its range in California is unknown, but its impacts can be significant, particularly in areas with small isolated populations (Kupferberg et al. 2009c, Kupferberg and Furey 2015). An example is the Carnegie State Vehicular Recreation Area (CVSRA), located in the hills southwest of Tracy in the Corral Hollow Creek watershed (Alameda and San Joaquin counties). The above-described road effects apply: sedimentation, crushing along trail crossings, and potential noise effects (Ibid.). In addition, dust suppression activities employed by CSVRA use magnesium chloride ($MgCl_2$), which has the potential to harm developing embryos and tadpoles (Karraker et al. 2008, Hopkins et al. 2013, OHMVRC 2017). Based on museum records, Foothill Yellow-legged Frogs were apparently abundant in Corral Hollow Creek, but they are extremely rare now and are already extirpated or at risk of extirpation (Kupferberg et al. 2009c, Kupferberg and Furey 2015).

Motorized and non-motorized recreational boating can also impact Foothill Yellow-legged Frogs. The impacts of jet boat traffic were investigated in Oregon; in areas with frequent use and high wakes breaking on shore, Foothill Yellow-legged Frogs were absent (Borisenko and Hayes 1999 as cited in Olson and Davis 2009). This wake action had the potential to dislodge egg masses, strand tadpoles, disrupt adult basking behavior, and erode shorelines (Ibid.). Jet boat tours and races on the Klamath River (Del Norte and Humboldt counties) may have an impact on Foothill Yellow-legged Frog use of the mainstem (M. van Hattem pers. comm. 2019). In addition, using gravel bars as launch and haul out sites for boat trailers, kayaks, or river rafts can result in direct loss of egg masses and tadpoles or damage to breeding and rearing habitat and can disrupt post-metamorphic frog behavior (Ibid.). As described above, pulse flows released for whitewater boating in the late spring and summer can result in scouring and stranding of egg masses and tadpoles (Borisenko and Hayes 1999 as cited in Olson and Davis 2009, Kupferberg et al. 2009b). In addition, the velocities that resulted in stunted growth and increased vulnerability to predation in Foothill Yellow-legged Frog tadpoles were less than the increased velocities experienced in nearshore habitats during intentional release of recreational flows for whitewater boating, as well as hydropeaking for power generation (Kupferberg et al. 2011b).

Hiking, horse-riding, camping, fishing, and swimming, particularly in sensitive breeding and rearing habitat can also adversely impact Foothill Yellow-legged Frog populations (Borisenko and Hayes 1999 in Olson and Davis 2009). Because Foothill Yellow-legged Frog breeding activity was being disturbed and egg masses were being trampled by people and dogs using Carson Falls (Marin County), the land manager established an educational program, including employing docents on weekends that remind people to stay on trails and tread lightly to try to reduce the loss of Foothill Yellow-legged Frog reproductive effort (Prado 2005). In addition, within his study site, Van Wagner (1996) reported that a property owner moved rocks that were being used as breeding habitat to create a swimming hole. The extent to which this is more than a small, local problem is unknown, but as the population of California increases, recreational pressures in Foothill Yellow-legged Frog habitat are likely to increase commensurately.

Drought

Drought is a common phenomenon in California and is characterized by lower than average precipitation. Lower precipitation in general results in less surface water, and water availability is critical for obligate stream-breeding species. Even in the absence of drought, a positive relationship exists between precipitation and latitude within the Foothill Yellow-legged Frog's range in California, and mean annual precipitation has a strong influence on Foothill Yellow-legged Frog presence at historically occupied sites (Davidson et al. 2002, Lind 2005). Figure 22 depicts the recent historical annual average precipitation across the state as well as during the most recent drought and how they differ. Southern California is normally drier than northern California, but the severity of the drought was even greater in the south.

Reduced precipitation can result in deleterious effects to Foothill Yellow-legged Frogs beyond the obvious premature drying of aquatic habitat. When stream flows recede during the summer and fall, sometimes the isolated pools that stay perennially wet are the only remaining habitat. This phenomenon concentrates aquatic species, resulting in several potentially significant adverse impacts. Stream flow volume was negatively correlated with Bd load during a recent chytridiomycosis outbreak in the Alameda Creek watershed (Adams et al. 2017a). The absence of high peak flows in winter coupled with wet years allowed bullfrogs to expand their distribution upstream, and the drought-induced low flows in the fall concentrated them with Foothill Yellow-legged Frogs in the remaining drying pools (Ibid.). This mass mortality event appeared to have been the result of a combination of drought, disease, and dam effects (Ibid.). This die-off occurred in a regulated reach that experiences heavy recreational use and presence of crayfish and bass (Ibid.). Despite these threats, the density of breeding females in this reach was greater in 2014 and 2015 than the in the unregulated reach upstream because the latter dried completely before tadpoles could metamorphose during the preceding drought years (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015).

In addition to increasing the spread of pathogens, drought-induced stream drying can increase predation and competition by introduced fish and frogs in the pools they are forced to share (Moyle 1973, Hayes and Jennings 1988, Drost and Fellers 1996). This concentration in isolated pools can also result in increased native predation as well as facilitate spread of Bd. An aggregation of six adult Foothill

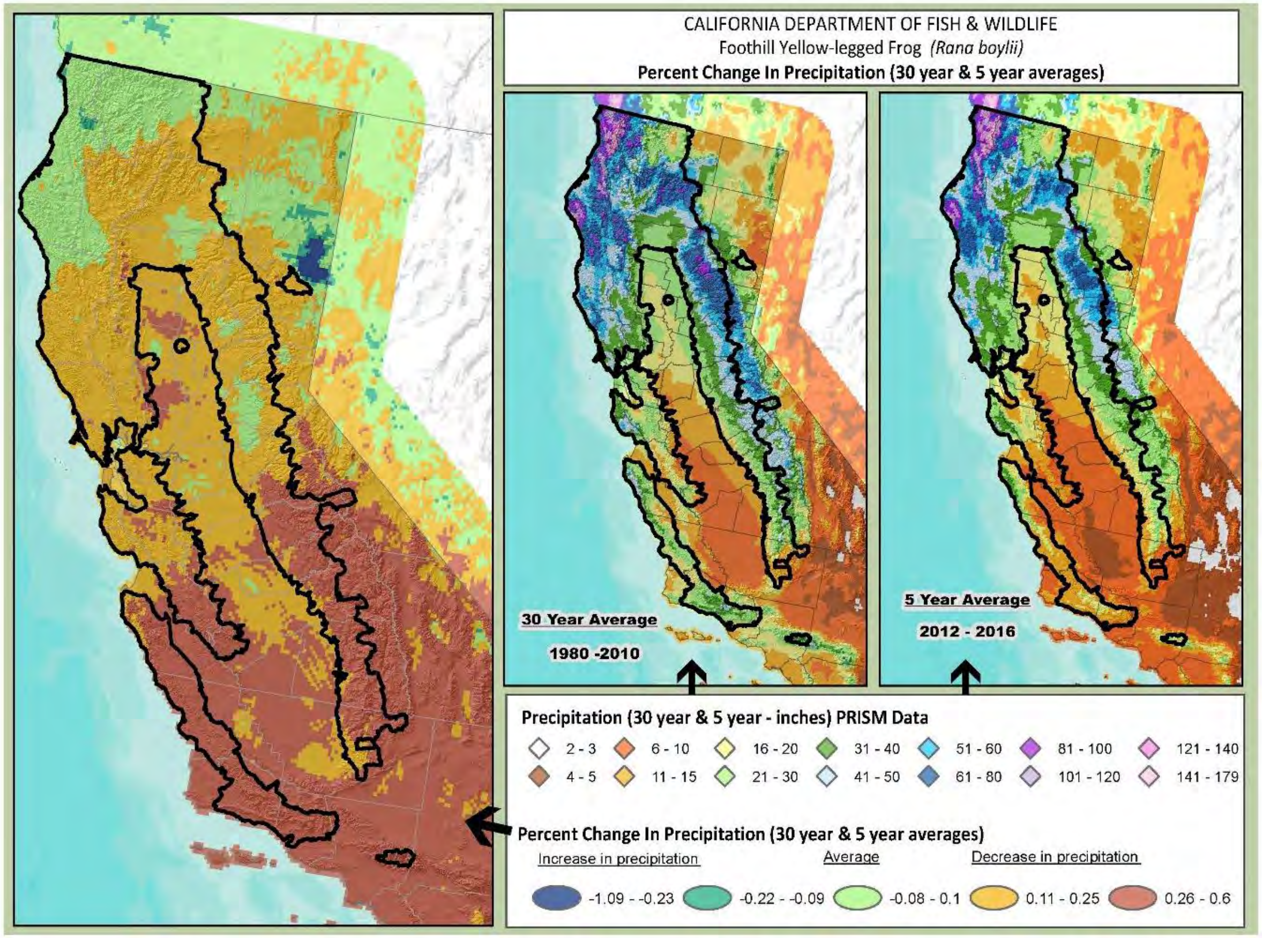

Figure 22. Change in precipitation from 30-year average and during the recent drought (PRISM)

Yellow-legged Frogs was observed perched on a rock above an isolated pool where a garter snake was foraging on tadpoles during the summer; this close contact may reduce evaporative water loss when they are forced out of the water during high temperatures, but it can also increase disease transmission risk (Leidy et al. 2009.). Gonsolin (2010) also documented a late summer aggregation of juvenile Foothill Yellow-legged Frogs out of water during extremely high temperatures. In addition, drought-induced low flow, high water temperatures, and high densities of tadpoles were associated with outbreaks of malformation-inducing parasitic copepods (Kupferberg et al. 2009a).

Rapidly receding spring flows can result in stranding egg masses and tadpoles. However, this risk is likely less significant when it is drought-induced on an unregulated stream vs. a result of dam operations since Foothill Yellow-legged Frogs have evolved to initiate breeding earlier and shorten the breeding period in drought years (Kupferberg 1996a). If pools stay wet long enough to support metamorphosis, complete drying at the end of the season may benefit Foothill Yellow-legged Frogs if it eliminates introduced species like warm water fish and bullfrogs. Moyle (1973) noted that the only intermittent streams occupied by Foothill Yellow-legged Frogs in the Sierra Nevada foothills had no bullfrogs. At a long-term study site in upper Coyote Creek in 2015, Foothill Yellow-legged Frogs had persisted in reaches that had at least some summer water through the three preceding years of the most severe drought in over a millennium, albeit at much lower abundance than a decade before (Gonsolin 2010, Griffin and Anchokaitis 2014, J. Smith pers. comm. 2015). The population's abundance appeared to have never recovered from the 2007-2009 drought before the 2012-2016 drought began (J. Smith pers. comm. 2015). In 2016, after a relatively wet winter, Foothill Yellow-legged Frogs bred en masse, and only a single adult bullfrog was detected, an unusually low number for that area (CDWR 2016, J. Smith pers. comm. 2016). It appeared the population may rebound; however, in 2018, it experienced lethal chytridiomycosis outbreak, and like the Alameda Creek die-off probably resulted from crowding during drought, presence of bullfrogs as Bd-reservoirs and predators and competitors, and the stress associated with the combination of the two (Kupferberg and Catenazzi 2019).

Drought effects can also exacerbate other environmental stressors. During the most recent severe drought, tree mortality increased dramatically from 2014 to 2017 and reached approximately 129 million dead trees (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are more prone to severe wildfires, and they lose their carbon sequestration function while also emitting methane, which is an extremely damaging greenhouse gas (CNRA 2016). Post-wildfire storms can result in erosion of fine sediments from denuded hillsides into the stream channel (Florsheim et al. 2017). If the storms are short duration and low precipitation, as happens during droughts, their magnitude may not be sufficient to transport the material downstream, resulting in a longer temporal loss or degradation of stream habitat (Ibid.). Reduced rainfall may also infiltrate the debris leading to subsurface flows rather than the surface water Foothill Yellow-legged Frogs require (Ibid.). Extended droughts increase risk of the stream being uninhabitable or inadequate for breeding for multiple years, which would result in population-level impacts and possible extirpation (Ibid.).

Wildland Fire and Fire Management

Fire is an important element for shaping and maintaining the species composition and integrity of many California ecosystems (Syphard et al. 2007, SBFFP 2018). Prior to European settlement, an estimated 1.8 to 4.9 million ha (4.5-12 million ac) burned annually (4-11% of total area of the state), ignited both deliberately by Native Americans and through lightning strikes (Keeley 2005, SBFFP 2018). The impacts of wildland fires on Foothill Yellow-legged Frogs are poorly understood and likely vary significantly across the species' range with differences in climate, vegetation, soils, stream-order, slope, frequency, and severity (Olson and Davis 2009). Mortality from direct scorching is unlikely because Foothill Yellow-legged Frogs are highly aquatic, and most wildfires occur during the dry period of the year when the frogs are most likely to be in or near the water (Pilliod et al. 2003, Bourque 2008). Field observations support this presumption; sightings of post-metamorphic Foothill Yellow-legged Frogs immediately after fires in the northern Sierra Nevada and North Coast indicate they are not very vulnerable to the direct effects of fire (S. Kupferberg and R. Peek pers. comm. 2018). Similarly, Foothill Yellow-legged Frogs were observed two months, and again one year, after a low- to moderate-intensity fire burned an area in the southern Sierra Nevada in 2002, and the populations were extant and breeding as recently as 2017 (Lind et al. 2003b, CNDDB 2019). While water may provide a refuge during the fire, it is also possible for temperatures during a fire, or afterward due to increased solar exposure, to near or exceed a threshold resulting in lethal or sublethal harm; this would likely impact embryos and tadpoles with limited dispersal abilities (Pilliod et al. 2003).

Intense fires remove overstory canopy, which provides insulation from extreme heat and cold, and woody debris that increases habitat heterogeneity (Pilliod et al. 2003, Olson and Davis 2009). If this happens frequently enough, it can permanently change the landscape. For example, frequent high-severity burning of crown fire-adapted ecosystems can prevent forest regeneration since seeds require sufficient time between fires to mature, and repeated fires can deplete the seed bank (Stephens et al. 2014). Smoke and ash change water chemistry through increased nutrient and heavy metal inputs that can reach concentrations harmful to aquatic species during the fire and for days, weeks, or years thereafter (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Erosion rates on granitic soils, which make up a large portion of the Foothill Yellow-legged Frog's range, can be over 60 times greater in burned vs. unburned areas and can increase sedimentation for over 10 years (Megahan et al. 1995, Hayes et al. 2016). Post-fire nutrient inputs into streams could benefit Foothill Yellow-legged Frogs through increased productivity and more rapid growth and development (Pilliod et al. 2003). While the loss of leaf litter that accompanies fire alters the food web, insects are expected to recolonize rapidly, and the lack of cover could increase their vulnerability to predation by Foothill Yellow-legged Frogs (Ibid.).

Low-intensity fires likely have no adverse effect on Foothill Yellow-legged Frogs (Olson and Davis 2009). If they occur in areas with dense canopy, wildfires can improve habitat quality for Foothill Yellow-legged Frogs by reducing riparian cover, providing areas to bask, and increasing habitat heterogeneity, which is likely to outweigh any adverse effects from some fire-induced mortality (Russell et al. 1999, Olson and Davis 2009). In a preliminary analysis of threats to Foothill Yellow-legged Frogs in Oregon, proximity to stand-replacing fires was not associated with absence (Olson and Davis 2009).

Euro-American colonization of California significantly altered the pattern of periodic fires with which California's native flora and fauna evolved through fire exclusion, land use practices, and development (OEHHA 2018). Fire suppression can lead to canopy closure, which reduces habitat quality by limiting thermoregulatory opportunities (Olson and Davis 2009). In addition, fire suppression and its subsequent increase in fuel loads combined with expanding urbanization and rising temperatures have resulted in a greater likelihood of catastrophic stand-replacing fires that can significantly alter riparian systems for decades (Pilliod et al. 2003). Firebreaks, in which vegetation is cleared from a swath of land, can result in similar impacts to roads and road construction (Ibid.). Fire suppression can also include bulldozing within streams to create temporary reservoirs for pumping water, which can cause more damage than the fire itself to Foothill Yellow-legged Frogs in some cases (S. Kupferberg and R. Peek pers. comm. 2018). In addition, fire suppression practices can involve applying hundreds of tons of ammonia-based fire retardants and surfactant-based fire suppressant foams from air tankers and fire engines (Pilliod et al. 2003). Some of these chemicals are highly toxic to some anurans (Little and Calfee 2000).

Fire suppression has evolved into fire management with a greater understanding of its importance in ecosystem health (Keeley and Syphard 2016). Several strategies are employed including prescribed burns, mechanical fuels reduction, and allowing some fires to burn instead of necessarily extinguishing them (Pilliod et al. 2003). Like wildfires themselves, fire management strategies have the potential to benefit or harm Foothill Yellow-legged Frogs. Prescribed fires and mechanical fuels removal lessen the likelihood of catastrophic wildfires, but they can also result in loss of riparian vegetation, excessive sedimentation, and increased water temperatures (Ibid.). Salvage logging after a fire may result in similar impacts to timber harvest but with higher rates of erosion and sedimentation (Ibid.). A balanced approach to wildland fires is likely to have the greatest beneficial impact on species and ecosystem health (Stephens et al. 2012).

Floods and Landslides

As previously described, Foothill Yellow-legged Frog persistence is highly sensitive to early life stage mortality (Kupferberg et al. 2009c). While aseasonal dam releases are a major source of egg mass and tadpole scouring, storm-driven floods are also capable of ~~it~~ inducing the same effects (Ashton et al. 1997). Van Wagner (1996) concluded that the high discharge associated with heavy rainfall could account for a significant source of mortality in post-metamorphic Foothill Yellow-legged Frogs as well as eggs and tadpoles; he observed two adult females and several juveniles swept downstream with fatal injuries post-flooding. Severe flooding, specifically two 500-year flood events in early 1969 in Evey Canyon (Los Angeles County), resulted in massive riparian habitat destruction (Sweet 1983). Prior to the floods, Foothill Yellow-legged Frogs were widespread and common, but only four subsequent sightings were documented between 1970 and 1974 and none since (Sweet 1983, Adams 2017b). Sweet (1983) speculates that because Foothill Yellow-legged Frogs overwinter in the streambed in that area, the floods may have reduced the population's abundance below an extinction threshold. Four other herpetologists interviewed about Foothill Yellow-legged Frog extirpations in southern California listed severe flooding as a likely cause (Adams et al. 2017b).

As mentioned above, landslides are a frequent consequence of post-fire rainstorms and can result in lasting impacts to stream morphology, water quality, and Foothill Yellow-legged Frog populations. On the other hand, Olson and Davis (2009) suggest that periodic landslides can have beneficial effects by transporting woody debris into the stream that can increase habitat complexity and by replacing sediments that are typically washed downstream over time. Whether a landslide is detrimental or beneficial is likely heavily influenced by amount of precipitation and the underlying system. As previously described, too little precipitation could lead to prolonged loss of habitat through failure to transport material downstream, and too much precipitation can result in large-scale habitat destruction and direct mortality.

Climate Change

Global climate change threatens biodiversity and may lead to increased frequency and severity of drought, wildfires, flooding, and landslides (Williams et al. 2008, Keely and Syphard 2016). Data show a consistent trend of warming temperatures in California and globally; 2014 was the warmest year on record, followed by 2015, 2017, and 2016 (OEHHA 2018). Climate model projections for annual temperature in California in the 21st century range from 1.5 to 4.5°C (2.7-8.1°F) greater than the 1961-1990 mean (Cayan et al. 2008). Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation, and increasingly dry conditions in California resulting from increased evaporative water loss primarily due to rising temperatures (Cayan et al. 2005, Williams et al. 2015, OEHHA 2018). Precipitation variability and proportion of dry years were negatively associated with Foothill Yellow-legged Frog presence in a range-wide analysis (Lind 2005). In addition, low precipitation intensified the adverse effects of dams on the species (Ibid.).

California recently experienced the longest drought since the U.S. Drought Monitor began reporting in 2000 (NIDIS 2019). Until March 5, 2019, California experienced drought effects in at least a portion of the state for 376 consecutive weeks; the most intense period occurred during the week of October 28, 2014 when D4 (the most severe drought category) affected 58.4% of California's land area (Figure 23; NIDIS 2019). A recent modeling effort using data on historical droughts, including the Medieval megadrought between 1100 and 1300 CE, indicates the mean state of drought from 2050 to 2099 in California will likely exceed the Medieval-era drought, under both high and moderate greenhouse gas emissions models (Cook et al. 2015). The probability of a multidecadal (35 yr) drought occurring during the late 21st century is greater than 80% in all models used by Cook et al. (2015). If correct, this would represent a climatic shift that not only falls outside of contemporary variability in aridity but would also be unprecedented in the past millennium (Ibid.).

As a result of increasing temperatures, a decreasing proportion of precipitation falls as snow, resulting in more runoff from rainfall during the winter and a shallower snowpack that melts more rapidly (Stewart 2009). A combination of reduced seasonal snow accumulation and earlier streamflow timing significantly reduces surface water storage capacity and increases the risk for winter and spring floods, which may require additional and taller dams and result in alterations to hydroelectric power generation flow regimes (Cayan et al. 2005, Knowles et al. 2006, Stewart 2009). The reduction in snowmelt volume

is expected to impact the northern Sierra (Feather, Yuba, and American River watersheds) to a greater extent than the southern portion (Young et al. 2009). The earlier shift in peak snowmelt timing is predicted to exceed four to six weeks across the entire Sierra Nevada depending on the amount of warming that occurs this century (Ibid.). In addition, the snow water equivalent is predicted to significantly decline by 2070-2099 over the 1961-1990 average in the Trinity, Sacramento, and San Joaquin drainages from -32% to -79%, and effectively no snow is expected to fall below 1000 m (3280 ft) in the high emissions/sensitive model (Cayan et al. 2008).

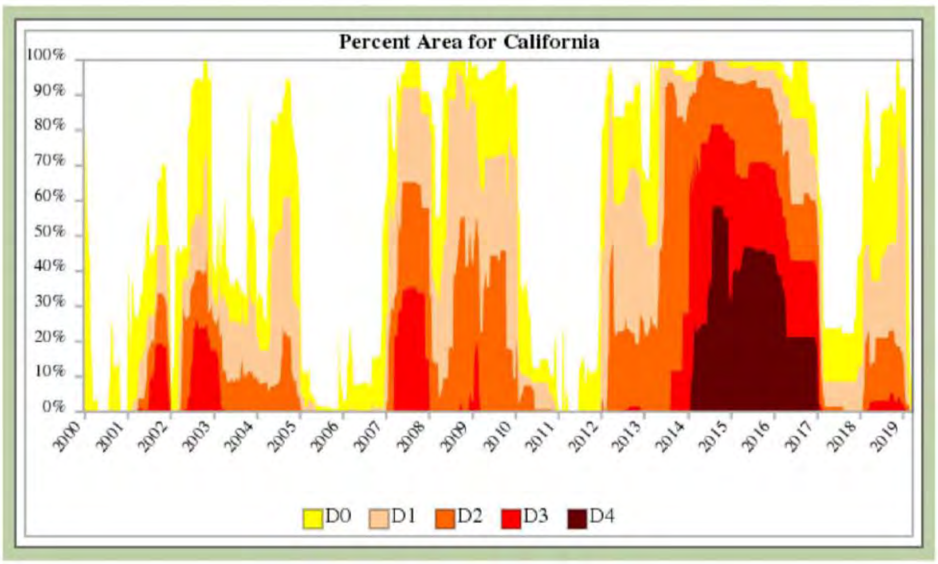

Figure 23. Palmer Hydrological Drought Indices 2000-present (NIDIS)

The earlier shift of snowmelt and lower water content will result in lower summer flows, which will intensify the competition for water among residential, agricultural, industrial, and environmental needs (Field et al. 1999, Cook et al. 2015). In unregulated systems, as long as water is present through late summer, an earlier hydrograph recession that triggers Foothill Yellow-legged Frog breeding could result in a longer time to grow larger prior to metamorphosis, which improves probability of survival (Yarnell et al. 2010, Kupferberg 2011b). However, if duration from peak to base flow shortens, it can result in increased sedimentation and reduced habitat complexity in addition to stranding (Yarnell et al. 2010).

Fire frequency relates to temperature, fuel loads, and fuel moisture (CCSP 2008). Therefore, increasing periods of drought combined with extreme heat and low humidity that stress or kill trees and other vegetation create ideal conditions for wildland fires (Ibid). Not surprisingly, the area burned by wildland fires over the western U.S. increased since 1950 but rose rapidly in the mid-1980s (Westerling et al. 2006, OEHHA 2018). As temperatures warmed and snow melted earlier, large-wildfire frequency and duration increased, and wildfire seasons lengthened (Westerling et al. 2006, OEHHA 2018).

In California, latitude inversely correlates with temperature and annual area burned, but the climate-fire relationship is substantially different across the state, and future wildfire regimes are difficult to predict (Keeley and Syphard 2016). For example, the relationship between spring and summer temperature and area burned in the Sierra Nevada is highly significant but not in southern California (Ibid.). Climate has a greater influence on fire regimes in mesic than arid environments, and the most influential climatological factor (e.g., precipitation, temperature, season, or their interactions) shifts over time (Ibid.). Nine of the 10 largest fires in California since 1932 have occurred in the past 20 years, 4 within the past 2 years (Figure 24; CAL FIRE 2019). However, it is possible this trend will not continue; climate- and wildfire-induced changes in vegetation could reduce wildfire severity in the future (Parks et al. 2016).

Wildfires themselves can accelerate the effects of climate change. Wildfires emit short-lived climate pollutants like black carbon (soot) and methane that are tens to thousands of times greater than carbon dioxide (the main focus of greenhouse gas reduction) in terms of warming effect and are responsible for 40% or more of global warming to date (CNRA 2016). Healthy forests can sequester large amounts of carbon from the atmosphere, but recently carbon emissions from wildfires have exceeded their uptake by vegetation in California (Ackerly et al. 2018).

With increased variability and changes in precipitation type, magnitude, and timing comes more variable and extreme stream flows (Mallakpour et al. 2018). Models for stream flow in California project higher high flows, lower low flows, wetter rainy seasons, and drier dry seasons (Ibid.). The projected water cycle extremes are related to strengthening El Niño and La Niña events, and both severe flooding and intense drought are predicted to increase by at least 50% by the end of the century (Yoon et al. 2015). These changes increase the likelihood of Foothill Yellow-legged Frog egg mass and tadpole scouring and stranding, even in unregulated rivers.

A species' vulnerability to climate change is a function of its sensitivity to climate change effects, its exposure to them, and its ability to adapt its behaviors to survive with them (Dawson et al. 2011). Myriad examples exist of species shifting their geographical distribution toward the poles and to higher elevations and changing their growth and reproduction with increases in temperature over time (Parmesan and Yohe 2003). However, in many places, fragmentation of suitable habitat by anthropogenic barriers (e.g., urbanization, agriculture, and reservoirs) limits a species' ability to shift its range (Pounds et al. 2007). The proportion of sites historically occupied by Foothill Yellow-legged Frogs that are now extirpated increases significantly on a north-to-south latitudinal gradient and at drier sites within California, suggesting climate change may contribute to the spatial pattern of the species' declines (Davidson et al. 2002).

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An analysis of the climate change sensitivity of 195 species of plants and animals in northwestern North America revealed that, as a group, amphibians and reptiles were estimated to be the most sensitive (Case et al. 2015). Nevertheless, examples exist of amphibians adjusting their breeding behaviors (e.g., calling and migrating to breeding sites) to occur earlier in the year as global warming increases (Beebee 1995, Gibbs and Breisch 2001). Because of the rapid change in temperature, Beebee (1995) posits these are examples of behavioral and physiological plasticity rather than natural selection. However, for

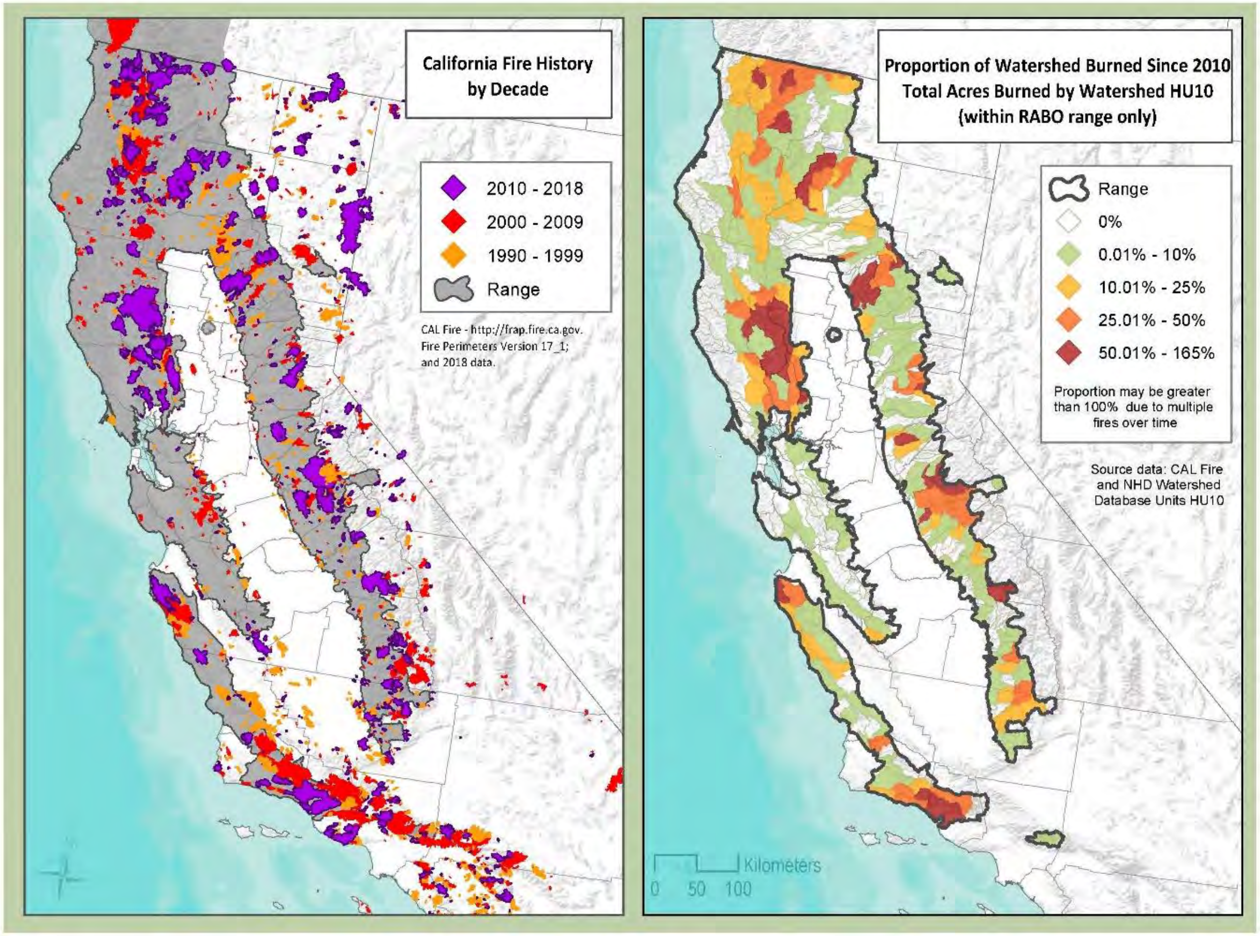


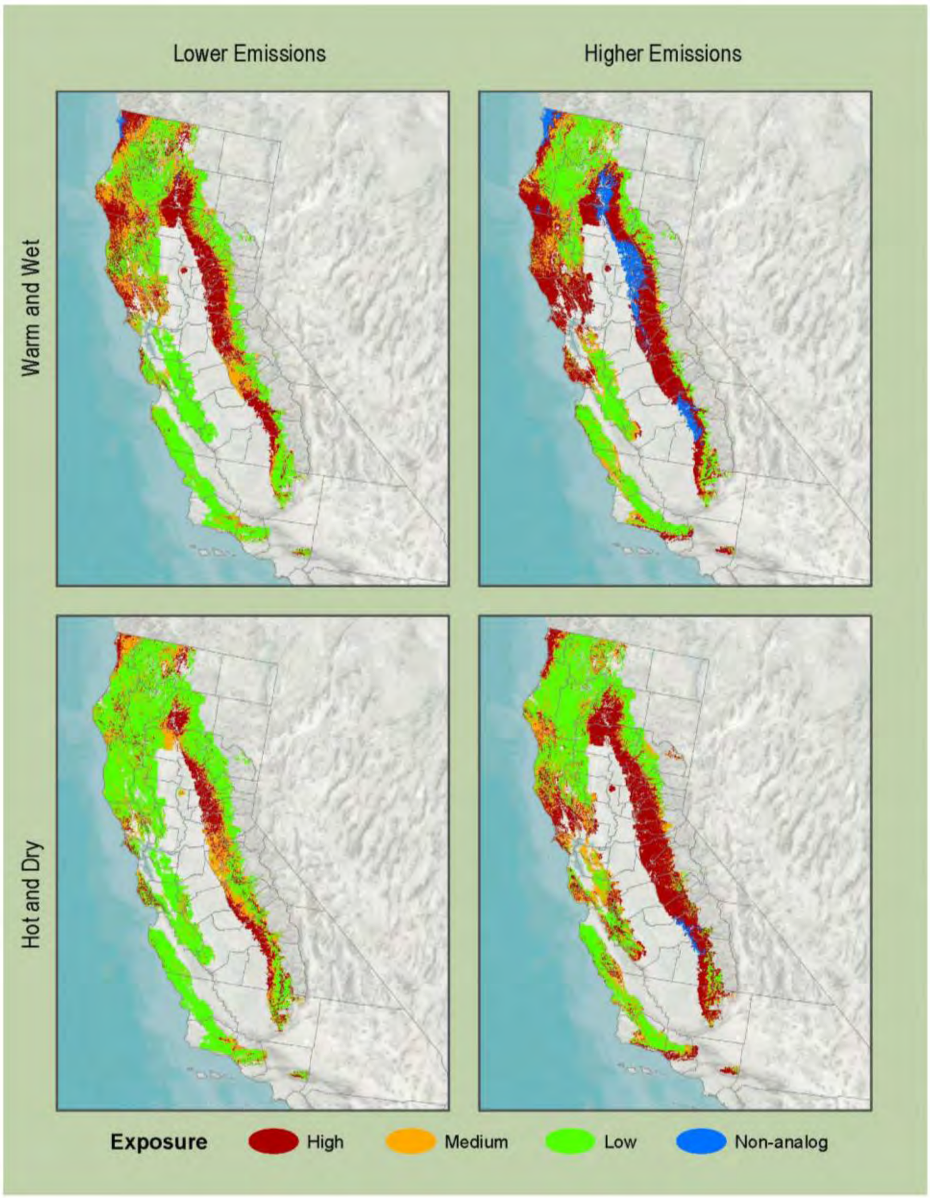
Figure 24. Fire history (1990-2018) and proportion of watershed burned (2010-2018) in California (CAL FIRE, NHD)

species with short generation times or in areas less affected by climate change, populations may be able to undergo evolutionary adaptation to the changing local environmental conditions (Hoffman and Sgrò 2011).

As previously described in the Seasonal Activity and Movements section, Foothill Yellow-legged Frog breeding is closely tied to water temperature, flow, and stage, and the species already adjusts its timing of oviposition by as much as a month in the same location during different water years, so the species may have enough inherent flexibility to reduce their vulnerability. The species appears fairly resilient to drought, fire, and flooding, at least in some circumstances. For example, after the 2012-2016 drought, the Loma Fire in late 2016, and severe winter flooding and landslides in 2016 and 2017, Foothill Yellow-legged Frog adults and metamorphs, as well as aquatic insects and rainbow trout, were abundant throughout Upper Llagas Creek in fall of 2017, and the substrate consisted of generally clean gravels and cobbles with only a slight silt coating in some pools (J. Smith pers. comm. 2017). The frogs and fish likely took refuge in a spring-fed pool, and the heavy rains scoured the fine sediments that eroded downstream (Ibid.). These refugia from the effects of climate change reduce the species' exposure, thereby reducing their vulnerability (Case et al. 2015).

Climate change models that evaluate the Foothill Yellow-legged Frog's susceptibility from a species and habitat perspective yield mixed results. An investigation into the possible effects of climate on California's native amphibians and reptiles used ecological niche models, future climate scenarios, and general circulation models to predict species-specific climatic suitability in 2050 (Wright et al. 2013). The results suggested approximately 90-100% of localities currently occupied by Foothill Yellow-legged Frogs are expected to remain climatically suitable in that time, and the proportion of currently suitable localities predicted to change ranges from -20% to 20% (Ibid.). However, a second study performed by the same research team using a subset of these models found that 66.4% of currently occupied cells will experience reduced environmental suitability in 2050 (Warren et al. 2014). This analysis included 90 species of native California mammals, birds, reptiles, and amphibians. For context, over half of the taxa were predicted to experience > 80% reductions, a consistent pattern reflected across taxonomic groups (Ibid.).

A third analysis investigated the long-term risk of climate change by modeling the relative environmental stress a vegetative community would undergo in 2099 given different climate and greenhouse gas emission scenarios (Thorne et al. 2016). This model does not incorporate any Foothill Yellow-legged Frog-specific data; it strictly projects climatic stress levels vegetative communities will experience within the species' range boundaries (Ibid.). Unsurprisingly, higher emissions scenarios resulted in a greater proportion of habitat undergoing climatic stress (Figure 25). Perhaps counterintuitively, the warm and wet scenario resulted in a greater amount of stress than the hot and dry scenario. When high emissions and warm and wet changes are combined, a much greater proportion of the vegetation communities will experience "non-analog" conditions, those outside of the range of conditions currently known in California (Ibid.).



Source - model extracts from -Thorne, J.H. et al. (2016) A climate change vulnerability assessment of California's terrestrial vegetation. CDFW.

Figure 25. Vegetative community exposure to climate change in 2099 based on Thorne et al. (2016).

Habitat Restoration and Species Surveys

Potential conflicts between managing riverine habitat below dams for both cold-water adapted salmonids and Foothill Yellow-legged Frogs was discussed previously. In addition to problems with temperatures and pulse flows, some stream restoration projects aimed at physically creating or improving salmonid habitat can also adversely affect the species. For example, boulder deflectors were placed in Hurdygurdy Creek (Del Norte County) to create juvenile steelhead rearing habitat; deflectors change broad, shallow, low-velocity reaches into narrower, deeper, faster reaches preferred by the fish (Fuller and Lind 1992). Foothill Yellow-legged Frogs were documented using the restoration reach as breeding habitat annually prior to placement of the boulders, but no breeding was detected in the following three years, suggesting this project eliminated the conditions the frogs require (Ibid.). In addition, a fish ladder to facilitate salmonid migration above the Alameda Creek Diversion Dam was recently constructed on a Foothill Yellow-legged Frog lek site, and the frogs may become trapped in the ladder (M. Grefsrud pers. comm. 2019). Use of rotenone to eradicate non-native fish as part of a habitat restoration project is rare, but if it is applied in streams occupied by Foothill Yellow-legged Frogs, it can kill tadpoles but is unlikely to impact post-metamorphic frogs (Fontenot et al. 1994). Metamorphosing tadpoles may be able to stay close enough to the surface to breathe air and survive but may display lethargy and experience increased susceptibility to predation (Ibid.).

Commonly when riparian vegetation is removed, regulatory agencies require a greater amount to be planted as mitigation to offset the temporal loss of habitat. This practice can have adverse impacts on Foothill Yellow-legged Frogs by reducing habitat suitability. Foothill Yellow-legged Frogs have been observed moving into areas where trees were recently removed, and they are known to avoid heavily shaded areas (Welsh and Hodgson 2011, M. Grefsrud pers. comm. 2019).

Biologists conducting surveys in Foothill Yellow-legged Frog habitat can trample egg masses or larvae if they are not careful. One method for sampling fish is electroshocking, which runs a current through the water that stuns the fish temporarily allowing them to be captured. Post-metamorphic frogs are unlikely to be killed by electroshocking; however, at high frequencies (60 Hz), they may experience some difficulty with muscle coordination for a few days (Allen and Riley 2012). This could increase their risk of predation. At 30 Hz, there were no differences between frogs that were shocked and controls (Ibid.). Tadpoles are more similar to fish in tail muscle and spinal structure and are at higher risk of injuries; however, researchers who reported observing stunned tadpoles noted they appeared to recover completely within several seconds (Ibid.). Adverse effects to Foothill Yellow-legged Frogs from electrofishing may only happen at frequencies higher than those typically used for fish sampling (Ibid.)

Small Population Sizes

Small populations are at greater risk of extirpation, primarily through the disproportionately greater impact of demographic, environmental, and genetic stochasticity on them compared to large populations, so any of the threats previously discussed will likely have an even greater adverse impact on small populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). This risk of extinction from genetic stochasticity is amplified when connectivity between the small populations, and thus gene flow,

is impeded (Fahrig and Merriam 1985, Taylor et al. 1993, Lande and Shannon 1996, Palstra and Ruzzante 2008). Genetic diversity provides capacity to evolve in response to environmental changes, and the "rescue effect" of gene flow is important in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). However, the rescue effect is diminished in conditions of high local environmental stochasticity of recruitment or survival (Eriksson et al. 2014). In addition, populations living near their physiological limits and lacking adaptive capacity may not be able to evolve in response to rapid changes (Hoffmann and Sgrò 2011). Furthermore, while pathogens or parasites rarely result in host extinction, they can increase its likelihood in small populations by driving the host populations below a critically low threshold beneath which demographic stochasticity can lead to extinction, even if they possess the requisite genetic diversity to adapt to a changed environment (Gomulkiewicz and Holt 1995, Adams et al. 2017b).

A Foothill Yellow-legged Frog PVA revealed that, even with no dam effects considered (e.g., slower growth and increased egg and tadpole mortality), populations with the starting average density of adult females in regulated rivers (4.6/km [2.9/mi]) were four times more likely to go extinct within 30 years than those with the starting average density of adult females from unregulated rivers (32/km [120/mi]) (Kupferberg et al. 2009c). When the density of females in sparse populations was used (2.1/km [1.3/mi], the 30-year risk of extinction increased 13-fold (Ibid.). With dam effects, a number of the risk factors above contribute to the additional probability of local extinction such as living near their lower thermal tolerance and reduced recruitment and survival from scouring and stranding flows, poor food quality, and increased predation and competition (Kupferberg 1997a; Hoffmann and Sgrò 2011; Kupferberg et al. 2011a,b; Kupferberg et al. 2012; Eriksson et al. 2014). These factors act synergistically, contributing in part to the small size, high divergence, and low genetic diversity exhibited by many Foothill Yellow-legged Frog populations located in highly regulated watersheds (Kupferberg et al. 2012, Peek 2018).

EXISTING MANAGEMENT

Land Ownership within the California Range

Using the Department's Foothill Yellow-legged Frog range boundary and the California Protected Areas Database (CPAD), a GIS dataset of lands that are owned in fee title and protected for open space purposes by over 1,000 public agencies or non-profit organizations, the total area of the species' range in California comprises 13,620,447 ha (33,656,857 ac) (CPAD 2019, CWHR 2019). Approximately 37% is owned by federal agencies, 80% of which (4,071,178 ha [10,060,100 ac]) is managed by the Forest Service (Figure 26). Department of Fish and Wildlife-managed lands, State Parks, and other State agency-managed lands constitute around 2.6% of the range. The remainder of the range includes < 1% Tribal lands, 2.3% other conserved lands (e.g., local and regional parks), and 57% private and government-managed lands that are not protected for open space purposes. It is important to note that even if included in the CPAD, a property's management does not necessarily benefit Foothill Yellow-legged Frogs, but in some cases changes in management to conserve the species may be easier to undertake than on private lands or public lands not classified as conserved.

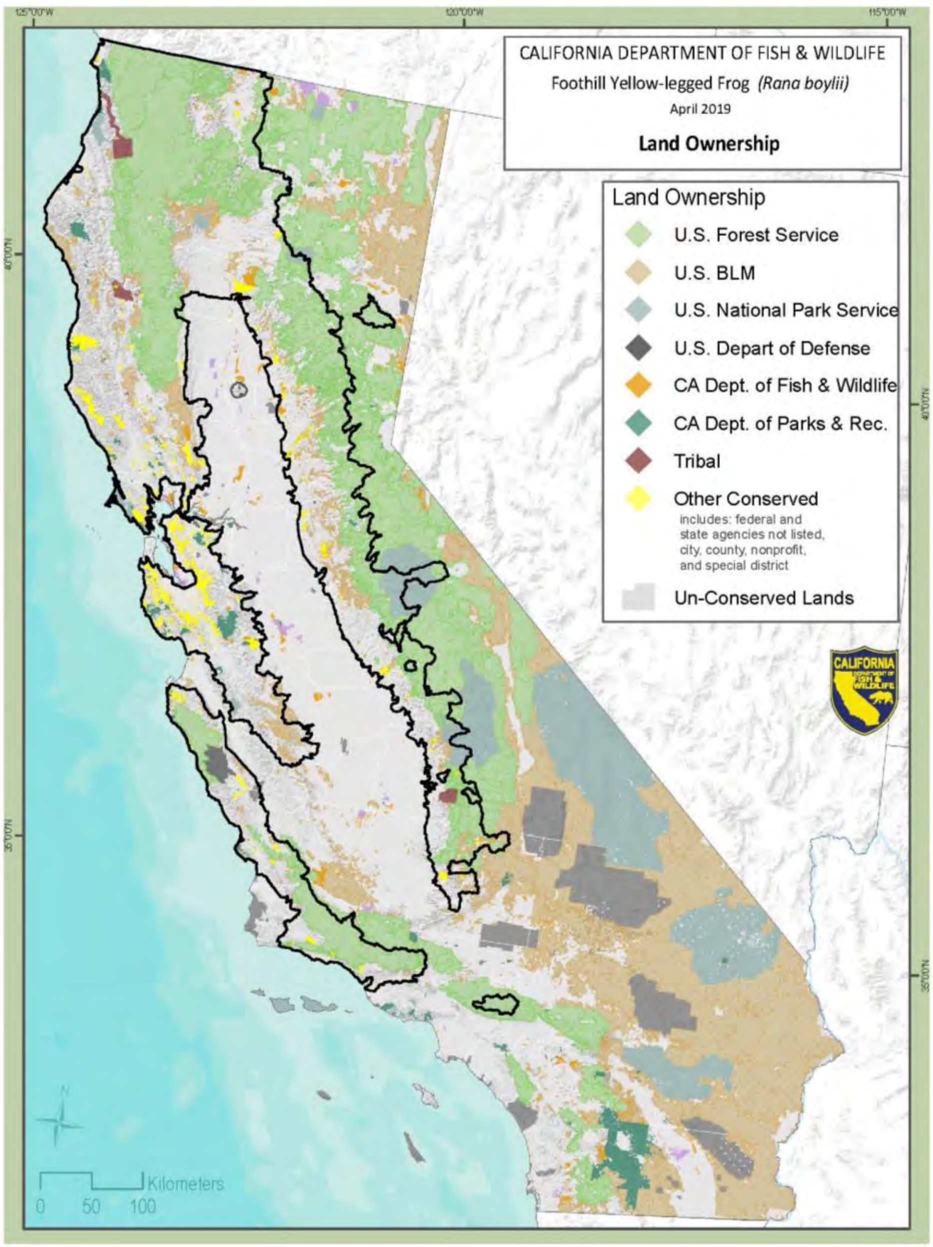


Figure 26. Conserved, Tribal, and other lands (BLM, CMD, CPAD, CWHR, DOD)

Statewide Laws

The laws and regulations governing land management within the Foothill Yellow-legged Frog's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California that may provide some level of protection for Foothill Yellow-legged Frogs and their habitat. The following is not an exhaustive list.

National Environmental Policy Act and California Environmental Quality Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. As a BLM and Forest Service Sensitive Species, impacts to Foothill Yellow-legged ~~Legged~~ Frogs are considered during NEPA analysis; however, the law has no requirement to minimize or mitigate adverse effects.

The California Environmental Quality Act (CEQA) is similar to NEPA; it requires state and local agencies to identify, analyze, and consider alternatives, and to publicly disclose environmental impacts from projects over which they have discretionary authority (Pub. Resources Code § 21000 et seq.). CEQA differs substantially from NEPA in requiring mitigation for significant adverse effects to a less than significant level unless overriding considerations are documented. CEQA requires an agency find projects that? may have a significant effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380.). CEQA establishes a duty for public agencies to avoid or minimize such significant effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to Foothill Yellow-legged Frogs, as an SSC, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA. However, a lead agency is not required to make a mandatory finding of significance conclusion unless it determines on a project-specific basis that the species meets the CEQA criteria for rare, threatened, or endangered.

Clean Water Act and Porter-Cologne Water Quality Control Act

The Clean Water Act originated in 1948 as the Federal Water Pollution Control Act of 1948. It was heavily amended in 1972 and became known as the Clean Water Act (CWA). The purpose of the CWA was to establish regulations for the discharge of pollutants into waters of the United States and establish quality standards for surface waters. Section 404 of the CWA forbids the discharge of dredged or fill material into waters and wetlands without a permit from the ACOE. The CWA also requires an alternatives analysis, and the ACOE is directed to issue their permit for the least environmentally damaging practicable alternative. The definition of waters of the United States has changed substantially over time based on Supreme Court decisions and agency rule changes.

The Porter-Cologne Water Quality Act was established by the State in 1969 and is similar to the CWA in that it establishes water quality standards and regulates discharge of pollutants into state waters, but it

also administers water rights which regulate water diversions and extractions. The SWRCB and nine Regional Water Boards share responsibility for implementation and enforcement of Porter-Cologne as well as the CWA's National Pollutant Discharge Elimination System permitting.

Federal and California Wild and Scenic Rivers Acts

In 1968, the U.S. Congress passed the federal Wild and Scenic Rivers Act (WSRA) (16 U.S.C. § 1271, et seq.) which created the National Wild and Scenic River System. The WSRA requires the federal government to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The WSRA prohibits the federal government from building, licensing, funding or otherwise aiding in the building of dams or other project works on rivers or segments of designated rivers. The WSRA does not give the federal government control of private property including development along protected rivers.

California's Wild and Scenic Rivers Act was enacted in 1972 so rivers that "possess extraordinary scenic, recreational, fishery, or wildlife values shall be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the state." (Pub. Res. Code, § 5093.50). Designated waterways are codified in Public Resources Code sections 5093.50-5093.70. In 1981, most of California's designated Wild and Scenic Rivers were adopted into the federal system. Currently in California, 3,218 km (1,999.6 mi) of 23 rivers are protected by the WSRA, most of which are located in the northwest. Foothill Yellow-legged Frogs have been observed in 11 of the 17 designated rivers within their range (CNDDB 2019).

Lake and Streambed Alteration Agreements

Fish and Game Code Section 1602 requires entities to notify the Department of activities that "divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake." If the activity may substantially adversely affect an existing fish and wildlife resource, the Department may enter into a lake or streambed alteration agreement with the entity that includes reasonable measures necessary to protect the fish or wildlife resource (Fish & G. Code, §1602, subd. (a)(4)(B)). A lake or stream alteration agreement does not authorize take of species listed as candidates, threatened, or endangered under CESA (see Protection Afforded by Listing for CESA compliance requirements).

Medicinal and Adult-Use Cannabis Regulation and Safety Act

The commercial cannabis cultivation industry is unique in that any entity applying for an annual cannabis cultivation license from California Department of Food and Agriculture (CDFA) must include "a copy of any final lake or streambed alteration agreement…or written verification from the California Department of Fish and Wildlife that a lake or streambed alteration agreement is not required" with their license application (Cal. Code Regs., tit. 3, § 8102, subd. (v)). The SWRCB also enforces the laws related to waste discharge and water diversions associated with cannabis cultivation (Cal. Code Regs., tit. 3, § 8102, subd. (p)).

Forest Practice Act

The Forest Practice Act was originally enacted in 1973 to ensure that logging in California is undertaken in a manner that will also preserve and protect the State's fish, wildlife, forests, and streams. This law and the regulations adopted by the California Board of Forestry and Fire Protection (BOF) pursuant to it are collectively referred to as the Forest Practice Rules. The Forest Practice Rules implement the provisions of the Forest Practice Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. The California Department of Forestry and Fire Protection (CAL FIRE) enforces these laws and regulations governing logging on private land.

Federal Power Act

The Federal Power Act and its major amendments are implemented and enforced by FERC and require licenses for dams operated to generate hydroelectric power. One of the major amendments required that these licenses "shall include conditions for the protection, mitigation and enhancement of fish and wildlife including related spawning grounds and habitat" (ECPA 1986). Hydropower licenses granted by FERC are usually valid for 30-50 years. If a licensee wants to renew their license, it must file a Notice of Intent and a pre-application document five years before the license expires to provide time for public scoping, any potentially new studies necessary to analyze project impacts and alternatives, and preparation of environmental documents. The applicant must officially apply for the new license at least two years before the current license expires.

As a federal agency, FERC must comply with federal environmental laws prior to issuing a new license or relicensing an existing hydropower project, which includes NEPA and ESA. As a result of environmental compliance or settlement agreements formed during the relicensing process, some operations have been modified and habitat restored to protect fish and wildlife. For example, the Lewiston Dam relicensing resulted in establishment of the Trinity River Restoration Program, which takes an ecosystem-approach to studying dam effects and protecting and restoring fish and wildlife populations downstream of the dam (Snover and Adams 2016). Similarly, relicensing of the Rock Creek-Cresta Project on the North Fork Feather River resulted in establishment of a multi-stakeholder Ecological Resources Committee (ERC). As a result of the ERC's studies and recommendations, pulse flows for whitewater boating were suspended for several years following declines of Foothill Yellow-legged Frogs, and the ERC is currently working toward augmenting the population in an attempt to increase abundance to a viable level.

Administrative and Regional Plans

Forest Plans

NORTHWEST FOREST PLAN

In 1994, BLM and the Forest Service adopted the Northwest Forest Plan to guide the management of over 97,000 km^2 (37,500 mi^2) of federal lands in portions of northwestern California, Oregon, and Washington. The Northwest Forest Plan created an extensive network of forest reserves including

Riparian Reserves. Riparian Reserves apply to all land designations to protect riparian dependent resources. With the exception of silvicultural activities consistent with Aquatic Conservation Strategy objectives, timber harvest is not permitted within Riparian Reserves, which can vary in width from 30 to 91 m (100-300 ft) on either side of streams, depending on the classification of the stream or waterbody (USFS and BLM 1994). Fuel treatment and fire suppression strategies and practices implemented within these areas are designed to minimize disturbance.

Sierra Nevada Forest Plan

Land and Resource Management Plans for forests in the Sierra Nevada were changed in 2001 by the Sierra Nevada Forest Plan Amendment and subsequently adjusted via a supplemental Environmental Impact Statement and Record of Decision in 2004, referred to as the Sierra Nevada Framework (USFS 2004). This established an Aquatic Management Strategy with Goals including maintenance and restoration of habitat to support viable populations of riparian-dependent species; spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction; instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats; the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity; and prevention of new introductions of invasive species and reduction of invasive species impacts that adversely affect the viability of native species. The Sierra Nevada Framework also includes Riparian Conservation Objectives and associated standards and guidelines specific to aquatic-dependent species, including the Foothill Yellow-legged Frog.

Resource Management Plans

Sequoia, Kings Canyon, and Yosemite National Parks fall within the historical range of the Foothill Yellow-legged Frog, but the species has been extirpated from these areas. The guiding principles for managing biological resources on National Park Service lands include maintenance of animal populations native to park ecosystems (Hayes et al. 2016). They also commit the agency to work with other land managers on regional scientific and planning efforts and maintenance or reintroduction of native species to the parks including conserving Foothill Yellow-legged Frogs in the Sierra Nevada (USDI NPS 1999 as cited in Hayes et al. 2016). A Sequoia and Kings Canyon National Parks Resource Management Plan does not include specific management goals for Foothill Yellow-legged Frogs, but it does include a discussion of the factors leading to the species' decline and measures to restore the integrity of aquatic ecosystems (Ibid.). The Yosemite National Park Resource Management Plan includes a goal of restoring Foothill Yellow-legged Frogs to the Upper Tuolumne River below Hetch Hetchy Reservoir (USDI NPS 2003 as cited in Hayes et al. 2016).

FERC Licenses

Dozens of hydropower dams have been relicensed in California since 1999, and several are in the process of relicensing (FERC 2019). In addition to following the Federal Power Act and other applicable federal laws, Porter-Cologne Water Quality Act requires non-federal dam operators to obtain a Water Quality Certification (WQC) from the SWRCB. Before it can issue the WQC, the SWRCB must consult with

the Department regarding the needs of fish and wildlife. Consequently, SWRCB includes conditions in the WQC that seek to minimize adverse effects to native species, and Foothill Yellow-legged Frogs have received some special considerations due to their sensitivity to dam operations during these licensing processes. As discussed above, the typical outcome is formation of an ERC-type group to implement the environmental compliance requirements and recommend changes to flow management to reduce impacts. Foothill Yellow-legged Frog-specific requirements fall into three general categories: data collection, modified flow regimes, and standard best management practices.

Data Collection

When little is known about the impacts of different flows and temperatures on Foothill Yellow-legged Frog occupancy and breeding success, data are collected and analyzed to inform recommendations for future modifications to operations such as temperature trigger thresholds. These surveys include locating egg masses and tadpoles, monitoring temperatures and flows, and recording their fate (e.g., successful development and metamorphosis, displacement, desiccation) during different flow operations and different water years. Examples of licenses with these conditions include the Lassen Lodge Project (FERC 2018), Rock Creek-Cresta Project (FERC 2009a), and El Dorado Project (EID 2007).

Modified Flow Regimes

When enough data exist to understand the effect of different operations on Foothill Yellow-legged Frog occupancy and success, license conditions may include required minimum seasonal instream flows, specific thermal regimes, gradual ramping rates to reduce the likelihood of early life stage scour or stranding, or freshet releases (winter/spring flooding simulation) to maintain riparian processes, and cancellation or prohibition of recreational pulse flows during the breeding season. Examples of licenses with these conditions include the Poe Hydroelectric Project (SWRCB 2017), Upper American Project (FERC 2014), and Pit 3, 4, 5 Project (FERC 2007b).

Best Management Practices

Efforts to reduce the impacts from maintenance activities and indirect operations include selective herbicide and pesticide application, aquatic invasive species monitoring and control, erosion control, and riparian buffers. Examples of licenses with these conditions include the South Feather Project (SWRCB 2018), Spring Gap-Stanislaus Project (FERC 2009b), and Chili Bar Project (FERC 2007a).

Habitat Conservation Plans and Natural Community Conservation Plans

Non-federal entities can obtain authorization for take of federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of a Habitat Conservation Plan (HCP) pursuant to Section 10 of the ESA. The take authorization can extend to species not currently listed under ESA but which may become listed as threatened or endangered over the term of the HCP, which is often 25-75 years. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. A Natural Community Conservation Plan (NCCP) identifies and provides for the protection of plants, animals, and their

habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs that include Foothill Yellow-legged Frogs as a covered species, two of which are also NCCPs.

HUMBOLDT REDWOOD (FORMERLY PACIFIC LUMBER) COMPANY

The Humboldt Redwood Company (HRC) HCP covers 85,672 ha (211,700 ac) of private Coast Redwood and Douglas-fir forest in Humboldt County (HRC 2015). It is a 50-year HCP/incidental take permit (ITP) that was executed in 1999, revised in 2015 as part of its adaptive management strategy, and expires on March 1, 2049. The HCP includes an Amphibian and Reptile Conservation Plan and an Aquatics Conservation Plan with measures designed to sustain viable populations of Foothill Yellow-legged Frogs and other covered aquatic herpetofauna. These conservation measures include prohibiting or limiting tree harvest within Riparian Management Zones (RMZ), controlling sediment by maintaining roads and hillsides, restricting controlled burns to spring and fall in areas outside of the RMZ, conducting effectiveness monitoring throughout the life of the HCP, and use the data collected to adapt monitoring and management plans accordingly.

Watershed assessment surveys include observations of Foothill Yellow-legged Frogs and have documented their widespread distribution on HRC lands with a pattern of fewer near the coast in the fog belt and more inland (S. Chinnici pers. comm. 2017). The watersheds within the property are largely unaffected by dam-altered flow regimes or non-native species, so aside from the operations described under Timber Harvest above that are minimized to the extent feasible, the focus on suitable temperatures and denser canopy cover for salmonids may reduce habitat suitability for Foothill Yellow-legged Frogs over time (Ibid.).

SAN JOAQUIN COUNTY MULTI-SPECIES HABITAT CONSERVATION AND OPEN SPACE PLAN

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) is a 50-year HCP/ITP that was signed by the USFWS on November 14, 2000 (San Joaquin County 2000). The SJMSCP covers almost all of San Joaquin County except federal lands, a few select projects, and some properties with certain land uses, roughly 364,000 ha (900,000 ac). At the time of execution, approximately 70 ha (172 ac) of habitat within the SJMSCP area in the southwest portion of the county were considered occupied by Foothill Yellow-legged Frogs with another 1,815 ha (4,484 ac) classified as potential habitat, but it appears the species had been considered extirpated before then (Jennings and Hayes 1994, San Joaquin County 2000, Lind 2005). The HCP estimates around 8% of the combined modeled habitat would be converted to other uses over the permit term, but the establishment of riparian preserves with buffers around Corral Hollow Creek, where the species occurred historically, was expected to offset those impacts (San Joaquin County 2000, SJCOG 2018). However, the HCP did not require surveys to determine if Foothill Yellow-legged Frogs are benefiting (M. Grefsrud pers. comm. 2019).

EAST CONTRA COSTA COUNTY HABITAT CONSERVATION PLAN/NATURAL COMMUNITY CONSERVATION PLAN

The East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan (ECCC HCP/NCCP) is a multi-jurisdictional 30-year plan adopted in 2007 that covers over 70,423 ha (174,018 ac) in eastern Contra Costa County (Jones & Stokes 2006). The Foothill Yellow-legged Frog appears to be

extirpated from the ECCC HCP/NCCP area (CNDDB 2019). Nevertheless, suitable habitat was mapped, and impacts were estimated at well under 1% of both breeding and migratory habitat (Jones & Stokes 2006). One of the HCP/NCCP's objectives is acquiring high-quality Foothill Yellow-legged Frog habitat that has been identified along Marsh Creek (Ibid.). In 2017, the Viera North Peak 65 ha (160 ac) property was acquired that possesses suitable habitat for Foothill Yellow-legged Frogs (ECCCHC 2018).

Santa Clara Valley Habitat Plan

The Santa Clara Valley Habitat Plan (SCVHP) is a 50-year HCP/NCCP covering over 210,237 ha (519,506 ac) in Santa Clara County (ICF 2012). As previously mentioned, Foothill Yellow-legged Frogs appear to have been extirpated from lower elevation sites, particularly below reservoirs in this area. Approximately 17% of modeled Foothill Yellow-legged Frog habitat, measured linearly along streams, was already permanently preserved, and the SCVHP seeks to increase that to 32%. The maximum allowable habitat loss is 11 km (7 mi) permanent loss and 3 km (2 mi) temporary loss, while 167 km (104 mi) of modeled habitat is slated for protection. By mid-2018, 8% of impact area had been accrued and 3% of habitat protected (SCVHA 2019).

Green Diamond Aquatic Habitat Conservation Plan

Green Diamond Resources Company has an Aquatic Habitat Conservation Plan (AHCP) covering 161,875 ha (400,000 ac) of their land that is focused on cold-water adapted species, but many of the conservation measures are expected to benefit Foothill Yellow-legged Frogs as well (K. Hamm pers. comm. 2017). Examples include slope stability and road management measures to reduce stream sedimentation from erosion and landslides, and limiting water drafting during low flow periods with screens over the pumps to avoid entraining animals (Ibid.). Although creating more open canopy areas and warmer water temperatures is not the goal of the AHCP, the areas that are suitable for Foothill Yellow-legged Frog breeding are likely to remain that way because they are wide channels that receive sufficient sunlight (Ibid.).

SUMMARY OF LISTING FACTORS

CESA's implementing regulations identify key factors relevant to the Department's analyses and the Fish and Game Commission's decision on whether to list a species as threatened or endangered. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

Present or Threatened Modification or Destruction of Habitat

Most of the factors affecting ability to survive and reproduce listed above involve destruction or degradation of Foothill Yellow-legged Frog habitat. The most widespread, and potentially most significant, threats are associated with dams and their flow regimes, particularly in areas where they are concentrated and occur in a series along a river. Dams and the way they are operated can have up- and downstream impacts to Foothill Yellow-legged Frogs. They can result in confusing natural breeding cues, scouring and stranding of egg masses and tadpoles, reducing quality and quantity of breeding and rearing habitat, reducing tadpole growth rate, impeding gene flow among populations, and establishing and spreading non-native species (Hayes et al. 2016). These impacts appear to be most severe when the dam is operated for the generation of hydropower utilizing hydropeaking and pulse flows (Kupferberg et al. 2009c, Peek 2018). Foothill Yellow-legged Frog abundance below dams is an average of five times lower than in unregulated rivers (Kupferberg et al. 2012). The number, height, and distance upstream of dams in a watershed influenced whether Foothill Yellow-legged Frogs still occurred at sites where they had been present in 1975 in California (Ibid.). Water diversions for agricultural, industrial, and municipal uses also reduce the availability and quality of Foothill Yellow-legged Frog habitat. Dams are concentrated in the Bay Area, Sierra Nevada, and southern California (Figure 17), while hydropower plants are densest in the northern and central Sierra Nevada (Figure 18).

With predicted increases in the human population, ambitious renewable energy targets, higher temperatures, and more extreme and variable precipitation falling increasingly ~~more~~ as rain rather than snow, the need for more and taller dams and water diversions for hydroelectric power generation, flood control, and water storage and delivery is not expected to abate in the future. California voters approved Proposition 1, the Water Quality, Supply and Infrastructure Improvement Act of 2014, which dedicated $2.7 billion to water storage projects (PPIC 2018). In 2018, the California Water Commission approved funding for four new dams in California: expansion of Pacheco Reservoir (Santa Clara County), expansion of Los Vaqueros Reservoir (Contra Costa County), Temperance Flat Dam (new construction) on the San Joaquin River (Fresno County), and the off-stream Sites Reservoir (new construction) diverting the Sacramento River (Colusa County) (CWC 2019). No historical records of Foothill Yellow-legged Frogs from the Los Vaqueros or Sites Reservoir areas exist in the CNDDB, and one historical (1950) collection is documented from the Pacheco Reservoir area (CNDDB 2019). However, the proposed Temperance Flat Dam site is downstream of one of the only known extant populations of Foothill Yellow-legged Frogs in the East/Southern Sierra clade (Ibid.).

The other widespread threat to Foothill Yellow-legged Frog habitat is climate change, although the severity of its impacts is somewhat uncertain. While drought, wildland fires, floods, and landslides are natural and ostensibly necessary disturbance events for preservation of native biodiversity, climate change is expected to result in increased frequency and severity of these events in ways that may exceed species' abilities to adapt (Williams et al. 2008, Hoffmann and Sgrò 2011, Keely and Syphard 2016). These changes can lead to increased competition, predation, and disease transmission as species become concentrated in areas that remain wet into the late summer (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Loss of riparian vegetation from wildland fires can result in increased stream temperatures or concentrations of nutrients and trace heavy metals that inhibit growth and survival

(Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Stream sedimentation from landslides following fire or excessive precipitation can destroy or degrade breeding and rearing habitat (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). At least some models predict unprecedented dryness in the latter half of the century (Cook et al. 2015). The effects of climate change will be realized across the Foothill Yellow-legged Frog's range, and their severity will likely differ in ways that are difficult to predict. However, the impacts from extended droughts will likely be greatest in the areas that are naturally more arid, the lower elevations and latitudes of southern California and the foothills surrounding the Central Valley (Figure 21).

While most future urbanization is predicted to occur in areas outside of the Foothill Yellow-legged Frog's range, it has already contributed to the loss and fragmentation of Foothill Yellow-legged Frog habitat in California. In addition, the increased predation, wildland fires, introduced species, road mortality, disease transmission, air and water pollution, and disturbance from recreation that can accompany urbanization expand its impact far beyond its physical footprint (Davidson et al. 2002, Syphard et al. 2007, Cook et al. 2012, Bar-Massada et al. 2014). Within the Foothill Yellow-legged Frog's historical range, these effects appear most significant and extensive in terms of population extirpations in southern California and the San Francisco Bay Area.

Several other activities have the potential to destroy or degrade Foothill Yellow-legged Frog habitat, but they are less common across the range. They also tend to have relatively small areas of impact, although they can be significant in those areas, particularly if populations are already small and declining. These include impacts from mining, cannabis cultivation, vineyard expansion, overgrazing, timber harvest, recreation, and some stream habitat restoration projects (Harvey and Lisle 1998, Belsky et al. 1999, Merelender 2000, Pilliod et al. 2003, Bauer et al. 2015, Kupferberg and Furey 2015).

Overexploitation

Foothill Yellow-legged Frogs are not threatened by overexploitation. There is no known pet trade for Foothill Yellow-legged Frogs (Lind 2005). During the massive frog harvest that accompanied the Gold Rush, some Foothill Yellow-legged Frogs were collected, but because they are relatively small and have irritating skin secretions, there was much less of a market for them (Jennings and Hayes 1985). Within these secretions is a peptide with antimicrobial activity that is particularly potent against *Candida albicans*, a human pathogen that has been developing resistance to traditional antifungal agents (Conlon et al. 2003). However, the peptide's therapeutic potential is limited by its strong hemolytic activity, so further studies will focus on synthesizing analogs that can be used as antifungals, and collection of Foothill Yellow-legged Frogs for lab cultures is unlikely (Ibid.).

Like all native California amphibians, collection of Foothill Yellow-legged Frogs is unlawful without a permit from the Department. They may only be collected for scientific, educational, or propagation reasons through a Scientific Collecting Permit (Fish & G. Code § 1002 et seq.). The Department has the discretion to limit or condition the number of individuals collected or handled to ensure no significant adverse effects. Incidental harm from authorized activities on other aquatic species can be avoided or minimized by the inclusion of special terms and conditions in permits.

Predation

Predation is a likely contributor to Foothill Yellow-legged Frog population declines where the habitat is degraded by one or many other risk factors (Hayes and Jennings 1986). Predation by native garter snakes can be locally substantial; however, it may only have an appreciable population-level impact if the availability of escape refugia is diminished. For example, when streams dry and only pools remain, Foothill Yellow-legged Frogs are more vulnerable to predation by native and non-native species because they are concentrated in a small area with little cover.

Several studies have demonstrated the synergistic impacts of predators and other stressors. Foothill Yellow-legged Frogs, primarily as demonstrated through studies on tadpoles, are more susceptible to predation when exposed to some agrochemicals, cold water, high velocities, excess sedimentation, and even the presence of other species of predators (Harvey and Lisle 1998, Adams et al. 2003, Olson and Davis 2009, Kupferberg et al. 2011b, Kerby and Sih 2015, Catenazzi and Kupferberg 2018). Foothill Yellow-legged Frog tadpoles appear to be naïve to chemical cues from some non-native predators; they have not evolved those species-specific predator avoidance behaviors (Paoletti et al. 2011). Furthermore, early life stages are often more sensitive to environmental stressors, making them more vulnerable to predation, and Foothill Yellow-legged Frog population dynamics are highly sensitive to egg and tadpole mortality (Kats and Ferrer, 2003, Kupferberg et al. 2009c). Predation pressure is likely positively associated with proximity to anthropogenic changes in the environment, so in more remote or pristine places, it probably does not have a serious population-level impact.

Competition

Intra- and interspecific competition in Foothill Yellow-legged Frogs has been documented. Intraspecific male-to-male competition for females has been reported (Rombough and Hayes 2007). Observations include physical aggression and a non-random mating pattern in which larger males were more often engaged in breeding (Rombough and Hayes 2007, Wheeler and Welsh 2008). A behavior resembling clutch-piracy, where a satellite male attempts to fertilize already laid eggs, has also been documented (Rombough and Hayes 2007). These acts of competition play a role in population genetics, but they likely do not result in serious physical injury or mortality. Intraspecific competition among Foothill Yellow-legged Frog tadpoles was negligible (Kupferberg 1997a).

Interspecific competition appears to have a greater possibility of resulting in adverse impacts. Kupferberg (1997a) did not observe a significant change in tadpole mortality for Foothill Yellow-legged Frogs raised with Pacific Treefrogs compared to single-species controls. However, when reared together, Foothill Yellow-legged Frog tadpoles lost mass, while Pacific Treefrog tadpoles increased mass (Kerby and Sih 2015). As described previously under Introduced Species, Foothill Yellow-legged Frog tadpoles experienced significantly higher mortality and smaller size at metamorphosis when raised with bullfrog tadpoles (Kupferberg 1997a). The mechanism of these declines appeared to be exploitative competition, as opposed to interference, through the reduction of available algal resources from bullfrog tadpole grazing in the shared enclosures (Ibid.).

The degree to which competition threatens Foothill Yellow-legged Frogs likely depends on the number and density of non-native species in the area rather than intraspecific competition, and co-occurrence of Foothill Yellow-legged Frog and bullfrog tadpoles may be somewhat rare since the latter tends to breed in lentic (still water) environments (M. van Hattem pers. comm. 2019). Interspecific competition with other native species may have some minor adverse consequences on fitness.

Disease

Currently, the only disease known to pose a serious risk to Foothill Yellow-legged Frogs is Bd. Until 2017, the only published studies on the impact of Bd on Foothill Yellow-legged Frogs suggested it could reduce growth and body condition but was not lethal (Davidson et al. 2007, Lowe 2009, Adams et al. 2017b). However, two recent mass mortality events caused by chytridiomycosis proved they are susceptible to lethal effects, at least under certain conditions like drought-related concentration and presence of bullfrogs (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Some evidence indicates disease may have played a principal role in the disappearance of the species from southern California (Adams et al. 2017b). Bd is likely present in the environment~~al~~ throughout the Foothill Yellow-legged Frog's range, and with bullfrogs and treefrogs acting as carriers, it will remain a threat to the species; however, given the dynamics of the two recent die-offs in the San Francisco Bay area, the probability of future outbreaks may be greater in areas where the species is under additional stressors like drought and introduced species (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Therefore, as with predation, Foothill Yellow-legged Frogs are less likely to experience the adverse impacts of diseases in more remote areas with fewer anthropogenic changes to the environment.

Other Natural Events or Human-Related Activities

Agrochemicals, particularly organophosphates that act as endocrine disruptors, can travel substantial distances from the area of application through atmospheric drift and have been implicated in the disappearance and declines of many species of amphibians in California including Foothill Yellow-legged Frogs (LeNoir et al. 1999, Davidson 2004, Lind 2005, Olson and Davis 2009). Foothill Yellow-legged Frogs appear to be significantly more sensitive to the adverse impacts of some pesticides than other native species (Sparling and Fellers 2009, Kerby and Sih 2015). These include smaller body size, slower development rate, increased time to metamorphosis, immunosuppression, and greater vulnerability to predation and malformations (Kiesecker 2002, Hayes et al. 2006, Sparling and Fellers 2009, Kerby and Sih 2015). Some of the most dramatic declines experienced by ranids in California occurred in the Sierra Nevada east of the San Joaquin Valley where over half of the state's total pesticide usage occurs (Sparling et al. 2001).

Many Foothill Yellow-legged Frog populations are small, isolated from other populations, and possess low genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). Genetic diversity is important in providing a population the capacity to evolve in response to environmental changes, and connectivity among populations is important for gene exchange and in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). Small populations are at much greater risk of extirpation primarily through the disproportionate impact of demographic, environmental, and genetic stochasticity than robust populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). Based on a Foothill Yellow-legged Frog PVA, populations in regulated rivers face a 4- to 13-fold greater extinction risk in 30 years than populations in unregulated rivers due to smaller population sizes (Kupferberg et al. 2009c). The threat posed by small population sizes is significant and the general pattern shows increases in severity from north to south; however, many sites, primarily in the northern Sierra Nevada, in watersheds with large hydropower projects are also at high risk.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). The conservation, protection, and enhancement of listed species and their habitat is of statewide concern (Fish & G. Code, § 2051(c)). CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86). The Fish and Game Code provides the Department with related authority to authorize "take" of species listed as threatened or endangered under certain circumstances (see, e.g., Fish & G. Code, §§ 2081, 2081.1, 2086, & 2835).

If the Foothill Yellow-legged Frog is listed under CESA, impacts of take caused by activities authorized through incidental take permits must be minimized and fully mitigated according to state standards (Fish & G. Code, § 2081, subd. (b)). These standards typically include protection of land in perpetuity with an easement, development and implementation of a species-specific adaptive management plan, and funding through an endowment to pay for long-term monitoring and maintenance to ensure the mitigation land meets performance criteria. Obtaining an incidental take permit is voluntary. The Department cannot force compliance; however, any person violating the take prohibition may be criminally and civilly liable under state law.

Additional protection of Foothill Yellow-legged Frogs following listing would be expected to occur through state and local agency environmental review under CEQA. CEQA requires affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on rare, threatened, and endangered species. In common practice, potential impacts to listed species are examined more closely in CEQA documents than potential impacts to unlisted species. Where significant impacts are identified under CEQA, the Department expects project-specific avoidance, minimization, and mitigation measures to benefit the species. State listing, in this respect, and consultation with the Department during state and local agency environmental review under CEQA, would be expected to benefit the Foothill Yellow-legged Frog in terms of reducing impacts from individual projects, which might otherwise occur absent listing.

For some species, CESA listing may prompt increased interagency coordination and the likelihood that state and federal land and resource management agencies will allocate funds toward protection and recovery actions. In the case of the Foothill Yellow-legged Frog, some multi-agency efforts exist, often associated with FERC license requirements, to improve habitat conditions and augment declining populations. The USFWS is leading an effort to develop regional Foothill Yellow-legged Frog conservation strategies, and CESA listing may result in increased priority for limited conservation funds.

LISTING RECOMMENDATION

CESA directs the Department to prepare this report regarding the status of the Foothill Yellow-legged Frog in California based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067).

The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science. In consideration of the scientific information contained herein, the Department has determined that listing the Foothill Yellow-legged Frog under CESA by genetic clade is the prudent approach due to the disparate degrees of imperilment among them. In areas of uncertainty, the Department recommends the higher protection status until clade boundaries can be better defined.

NORTHWEST/NORTH COAST: Not warranted at this time.

Clade-level Summary: This is the largest clade with the most robust populations (highest densities) and the greatest genetic diversity. This area is the least densely populated by humans; contains relatively few hydroelectric dams, particularly further north; and has the highest precipitation in the species' California range. The species is still known to occur in most, if not all, historically occupied watersheds; presumed extirpations are mainly concentrated in the southern portion of the clade around the heavily urbanized San Francisco Bay area. The proliferation of cannabis cultivation, particularly illicit grows in and around the Emerald Triangle, the apparent increase in severe wildland fires in the area, and potential climate change effects are cause for concern, so the species should remain a Priority 1 SSC here with continued monitoring for any change in its status.

WEST/CENTRAL COAST: Endangered.

Clade-level Summary: Foothill Yellow-legged Frogs appear to be extirpated from a relatively large proportion of historically occupied sites within this clade, particularly in the heavily urbanized northern portion around the San Francisco Bay. In the northern portion of the clade, nearly all the remaining populations (which may be fewer than a dozen) are located above dams, which line the mountains surrounding the Bay Area, and two are known to have undergone recent disease-associated die-offs. These higher elevation sites are more often intermittent or ephemeral streams than the lower in the watersheds. As a result, the more frequent and extreme droughts that have dried up large areas seem to have contributed to recent declines. Illegal cannabis cultivation, historical mining effects, overgrazing, and recreation likely contributed to declines and may continue to threaten remaining populations.

SOUTHWEST/SOUTH COAST: Endangered.

Clade-level Summary: The most extensive extirpations have occurred in this clade, and only two known extant populations remain. Both are small with apparently low genetic diversity, making them especially vulnerable to extirpation. This is also an area with a large human population, many dams, and naturally arid, fire-prone environments, particularly in the southern portion of the clade. Introduced species are widespread, and cannabis cultivation is rivaling the Emerald Triangle in some areas (e.g., Santa Barbara County). Introduced species, expanded recreation, disease, and flooding appear to have contributed to the widespread extirpations in southern California over 40 years ago.

FEATHER RIVER: Threatened.

Clade-level Summary: This is the smallest clade and has a high density of hydroelectric dams. It also recently experienced one of the largest, most catastrophic wildfires in California history. Despite these threats, Foothill Yellow-legged Frogs appear to continue to be relatively broadly distributed within the clade, although with all the dams in the area, most populations are likely disconnected. The area is more mesic and experienced less of a change in precipitation in the most recent drought than the clades south of it. The clade is remarkable genetically and morphologically as it is the only area where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs overlap and can hybridize. The genetic variation within the clade is greater than the other clades except for the Northwest/North Coast. Most of the area within the clade's boundaries is Forest Service-managed, and little urbanization pressure or known extirpations exist in this area. Recent FERC licenses in this area require Foothill Yellow-legged Frog specific conservation, which to date has included cancelling pulse flows, removing encroaching vegetation, and translocating egg masses and in situ head-starting to augment a population that had recently declined.

NORTHEAST/NORTHERN SIERRA: Threatened.

Clade-level Summary: The Northeast/Northern Sierra clade shares many of the same threats as the Feather River clade (e.g., relatively small area with many hydroelectric dams). The area is also more mesic and experienced less of a change in precipitation during the recent drought than more southern clades. However, this pattern may not continue as some models suggest loss of snowmelt will be greater in the northern Sierra Nevada, and one of the climate change exposure models suggests a comparatively large proportion of the lower elevations will experience climatic conditions not currently known from the area (i.e., non-analog) by the end of the century. Recent surveys suggest the area continues to support several populations of the species, some of which seem to remain robust, with a fairly widespread distribution. However, genetic analyses from several watersheds suggest many of these populations are isolated and diverging, particularly in regulated reaches with hydropeaking flows.

EAST/SOUTHERN SIERRA: Endangered.

Clade-level Summary: Like the Southwest/South Coast clade, widespread extirpations in this area were observed as early as the 1970s. Dams and introduced species were credited as causal factors in these declines in distribution and abundance, and mining and disease may also have contributed. This area is relatively arid, and drought effects appear greater here than in northern areas that exhibit both more precipitation and a smaller difference between drought years and the historical average. There is a relatively high number of hydroelectric power generating dams in series along the major rivers in this clade and at least one new proposed dam near one of the remaining populations. This area is also the most heavily impacted by agrochemicals from the San Joaquin Valley.

MANAGEMENT RECOMMENDATIONS

The Department has evaluated existing management recommendations and available literature applicable to the management and conservation of the Foothill Yellow-legged Frog to arrive at the following recommendations. These recommendations, which represent the best available scientific information, are largely derived ~~the~~ from the Foothill Yellow-legged Frog Conservation Assessment, the California Energy Commission's Public Interest Energy Research Reports, the Recovery Plans of West Coast Salmon and Steelhead, and the California Amphibian and Reptile Species of Special Concern (Kupferberg et al. 2009b,c; 2011a; NMFS 2012, 2013, 2014, 2016; Hayes et al. 2016, Thomson et al. 2016).

Conservation Strategies

Maintain current distribution and genetic diversity by protecting existing Foothill Yellow-legged Frog populations and their habitats and providing opportunities for genetic exchange. Increase abundance to viable levels in populations at risk of extirpation due to small sizes, when appropriate, through in situ or ex situ captive rearing and/or translocations. Use habitat suitability and hydrodynamic habitat models to identify historically occupied sites that may currently support Foothill Yellow-legged Frogs, or they could with minor habitat improvements or modified management. Re-establish extirpated populations in suitable habitat through captive propagation, rearing, and/or translocations. Prioritize areas in the southern portions of the species' range where extirpations and loss of diversity have been the most severe.

If establishing reserves, prioritize areas containing high genetic variation in Foothill Yellow-legged Frogs (and among various native species) and climatic gradients where selection varies over small geographical area because environmental heterogeneity can provide a means of maintaining phenotypic variability which increases the adaptive capacity of populations as conditions change. These reserves should provide connectivity to other occupied areas to facilitate gene flow and allow for ongoing selection to fire, drought, thermal stresses, and changing species interactions.

Research and Monitoring

Attempt to rediscover potentially remnant populations in areas where they are considered extirpated, prioritizing the southern portions of the species' range. Collect environmental DNA in addition to conducting visual encounter surveys to improve detectability. Concurrently assess presence of threats and habitat suitability to determine if future reintroductions may be possible. Collect genetic samples from any Foothill Yellow-legged Frogs captured for use in landscape genomics analyses and possible future translocation or captive propagation efforts. Attempt to better clarify clade boundaries where there is uncertainty. Study whether small populations are at risk of inbreeding depression, whether genetic rescue should be attempted, and if so, whether that results in hybrid vigor or outbreeding depression.

Continue to evaluate how water operations affect Foothill Yellow-legged Frog population demographics. Establish more long-term monitoring programs in regulated and unregulated (reference) rivers across the species' range but particularly in areas like the Sierra Nevada where most large hydropower dams in the species' range are concentrated. Assess whether the timing of pulse flows influences population dynamics, particularly whether early releases have a disproportionately large adverse effect by eliminating the reproductive success of the largest, most fecund females, who appear to breed earlier in the season. Investigate survival rates in poorly-understood life stages, such as tadpoles, young of the year, and juveniles. Determine the extent to which pulse flows contribute to displacement and mortality of post-metamorphic life stages.

Collect habitat variables that correlate with healthy populations to develop more site-specific habitat suitability and hydrodynamic models. Study the potential synergistic effect of increased flow velocity and decreased temperature on tadpole fitness. Examine the relationship between changes in flow, breeding and rearing habitat connectivity, and scouring and stranding to develop site-specific benign ramping rates. Incorporate these data and demographic data into future PVAs for use in establishing frog-friendly flow regimes in future FERC relicensing or license amendment efforts and habitat restoration projects. Ensure long-term funding for post-license or restoration monitoring to evaluate attainment of expected results and for use in adapting management strategies accordingly.

Evaluate the distribution of other threats such as cannabis cultivation, vineyard expansion, livestock grazing, mining, timber harvest, and urbanization and roads in the Foothill Yellow-legged Frog's range. Study the short- and long-term effects of wildland fires and fire management strategies. Assess the extent to which these potential threats pose a risk to Foothill Yellow-legged Frog persistence in both regulated and unregulated systems.

Investigate how reach-level or short-distance habitat suitability and hydrodynamic models can be extrapolated to a watershed level. Study habitat connectivity needs such as the proximity of breeding sites and other suitable habitats along a waterway necessary to maintain gene flow and functioning meta-population dynamics.

Habitat Restoration and Watershed Management

Remove or update physical barriers like dams and poorly constructed culverts and bridges to improve connectivity and natural stream processes. Remove anthropogenic features that support introduced predators and competitors such as abandoned mine tailing ponds that support bullfrog breeding. Conduct active eradication and management efforts to decrease the abundance of bullfrogs, non-native fish, and crayfish (where they are non-native). In managed rivers, manipulate stream flows to negatively affect non-native species not adapted to a winter flood/summer drought flow regime.

Adopt a multi-species approach to channel restoration projects and managed flow regimes (thermal, velocity, timing) and mimic the natural hydrograph to the greatest extent possible. When this is impractical or infeasible, focus on minimizing adverse impacts by gradually ramping discharge up and down, creating and maintaining gently sloping and sun-lit gravel bars and warm calm edgewater habitats for tadpole rearing, and mixing hypolimnetic water (from the lower colder stratum in a reservoir) with warmer surface water before release if necessary to ensure appropriate thermal conditions for successful metamorphosis. Promote restoration and maintenance of habitat heterogeneity (different depths, velocities, substrates, etc.) and connectivity to support all life stages and gene flow. Avoid damaging Foothill Yellow-legged Frog breeding habitat when restoring habitat for other focal species like anadromous salmonids.

Regulatory Considerations and Best Management Practices

Develop range-wide minimum summer baseflow requirements that protect Foothill Yellow-legged Frogs and their habitat with appropriate provisions to address regional differences using new more ecologically-meaningful approaches such as modified percent-of-flow strategies for watersheds (e.g., Mierau et al. 2018). Limit water diversions during the dry season and construction of new dams by focusing on off-stream water storage strategies.

Ensure and improve protection of riparian systems. Require maintenance of appropriate riparian buffers and canopy coverage (i.e., partly shaded) around occupied habitat or habitat that has been identified for potential future reintroductions. Restrict instream work to dry periods where possible. Prohibit fording in and around breeding habitat. Avoid working near streams after the first major rains in the fall when Foothill Yellow-legged Frogs may be moving upslope toward tributaries and overwintering sites. Use a 3 mm (0.125 in) mesh screen on water diversion pumps and limit the rate and amount of water diverted such that depth and flow remain sufficient to support Foothill Yellow-legged Frogs of all life stages occupying the immediate area and downstream. Install exclusion fencing where appropriate, and if Foothill Yellow-legged Frog relocation is required, conduct it early in the season because moving egg masses is easier than moving tadpoles.

Reduce habitat degradation from sedimentation, pesticides, herbicides, and other non-point source waste discharges from adjacent land uses including along tributaries of rivers and streams. Limit mining to parts of rivers not used for oviposition, such as deeper pools or reaches with few tributaries, and at times of year when frogs are more common in tributaries (i.e., fall and winter). Manage recreational activities in or adjacent to Foothill Yellow-legged Frog habitat (e.g., OHV and hiking trails, camp sites, boating ingress/egress, flows, and speeds) in a way that minimizes adverse impacts. Siting cannabis grows in areas with better access to roads, gentler slopes, and ample water resources could significantly reduce threats to the environment. Determine which, when, and where agrochemicals should be restricted to reduce harm to Foothill Yellow-legged Frogs and other species. Ensure all new road crossings and upgrades to existing crossings (bridges, culverts, fills, and other crossings) accommodate at least 100-year flood flows and associated bedload and debris.

Partnerships and Coordination

Establish collaborative partnerships with agencies, universities, and non-governmental organizations working on salmon and steelhead recovery and stream restoration. Anadromous salmonids share many of the same threats as Foothill Yellow-legged Frogs, and recovery actions such as barrier removal, restoration of natural sediment transport processes, reduction in pollution, and eradication of non-native predators would benefit frogs as well. Ensure Integrated Regional Water Management Plans and fisheries restoration programs take Foothill Yellow-legged Frog conservation into consideration during design, implementation, and maintenance.

Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems. Promote and implement initiatives and programs that improve water conservation use efficiency, reduce greenhouse gas emissions, promote sustainable agriculture and smart urban growth, and protect and restore riparian ecosystems. Shift reliance from on-stream storage to off-stream storage, resolve frost protection issues (water withdrawals), and ensure necessary flows for all life stages in all water years.

Establish a Department-coordinated staff and citizen scientist program to systematically monitor occupied stream reaches across the species' range.

Education and Enforcement

Support programs to provide educational outreach and local involvement in restoration and watershed stewardship, such as Project Wild, Adopt a Watershed, school district environmental camps, and other programs teaching the effects of human land and water use on Foothill Yellow-legged Frog survival.

Provide additional funding for increased law enforcement to reduce ecologically harmful stream alterations and water pollution and to ensure adequate protection for Foothill Yellow-legged Frogs at pumps and diversions. Identify and address illegal water diverters and out-of-compliance diverters, seasons of diversion, off-stream reservoirs, well pumping, and bypass flows to protect Foothill Yellow-legged Frogs. Prosecute violators accordingly.

ECONOMIC CONSIDERATIONS

The Department is charged in an advisory capacity in the present context to provide a written report and a related recommendation to the Commission based on the best scientific information available regarding the status of Foothill Yellow-legged Frog in California. The Department is not required to prepare an analysis of economic impacts (See Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

REFERENCES

Literature Cited

Ackerly, D., A. Jones, M. Stacey, and B. Riordan. 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.

Adams, A.J., S.J. Kupferberg, M.Q. Wilber, A.P. Pessier, M. Grefsrud, S. Bobzien, V.T. Vredenburg, and C.J. Briggs. 2017a. Extreme Drought, Host Density, Sex, and Bullfrogs Influence Fungal Pathogen Infections in a Declining Lotic Amphibian. Ecosphere 8(3):e01740. DOI: 10.1002/ecs2.1740.

Adams, A.J., A.P. Pessier, and C.J. Briggs. 2017b. Rapid Extirpation of a North American Frog Coincides with an Increase in Fungal Pathogen Prevalence: Historical Analysis and Implications for Reintroduction. Ecology and Evolution 7(23):10216-10232. DOI: 10.1002/ece3.3468

Adams, M.J., C.A. Pearl, and R.B. Bury. 2003. Indirect Facilitation of an Anuran Invasion by Non-native Fishes. Ecology Letters 6:343-351.

Allen, M., and S. Riley. 2012. Effects of Electrofishing on Adult Frogs. Unpublished report prepared by Normandeau Associates, Inc., Arcata, CA.

Alpers, C.N., M.P. Hunerlach, J.T. May, R.L. Hothem, H.E. Taylor, R.C. Antweiler, J.F. De Wild, and D.A. Lawler. 2005. Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999–2001: U.S. Geological Survey Scientific Investigations Report 2004-5251.

Alston, J.M., J.T. Lapsley, and O. Sambucci. 2018. Grape and Wine Production in California. Pp. 1-28 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/a1/1e/a11eb90f-af2a-4deb-ae58-9af60ce6aa40/grape_and_wine_production.pdf

American Bankers Association [ABA]. 2019. Marijuana and Banking. Website accessed on April 5, 2019 at https://www.aba.com/advocacy/issues/pages/marijuana-banking.aspx

Ashton, D.T. 2002. A Comparison of Abundance and Assemblage of Lotic Amphibians in Late-Seral and Second-Growth Redwood Forests in Humboldt County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Ashton, D.T., J.B. Bettaso, and H.H. Welsh, Jr. 2010. Foothill Yellow-legged Frog (*Rana boylii*) Distribution and Phenology Relative to Flow Management on the Trinity River. Oral presentation provided at the Trinity River Restoration Program's 2010 Trinity River Science Symposium 13 January 2010. http://www.trrp.net/library/document/?id=410

Ashton, D.T., A.J. Lind, and K.E. Schlick. 1997. Foothill Yellow-Legged Frog (*Rana boylii*) Natural History. USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA.

Ashton, D.T., and R.J. Nakamoto. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 38(4):442.

Baird, S.F. 1854. Descriptions of New Genera and Species of North American Frogs. Proceedings of the Academy of Natural Sciences of Philadelphia 7:62.

Bar-Massada, A., V.C. Radeloff, and S.I. Stewart. 2014. Biotic and Abiotic Effects of Human Settlements in the Wildland–Urban Interface. BioScience 64(5):429–437.

Bauer S.D., J.L. Olson, A.C. Cockrill, M.G. van Hattem, L.M. Miller, M. Tauzer, and G. Leppig. 2015. Impacts of Surface Water Diversions for Marijuana-Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLoS ONE 10(3):e0120016. https://doi.org/10.1371/journal.pone.0120016

Bee, M.A., and E.M. Swanson. 2007. Auditory Masking of Anuran Advertisement Calls by Road Traffic Noise. Animal Behaviour 74:1765-1776.

Beebee, T.J.C. 1995. Amphibian Breeding and Climate. Nature 374:219-220.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing in the Riparian Zone: Impact and Management Perspectives. Pp. 184-189 *In* R.D. Johnson and J.F. McCormick (Technical Coordinators). Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, U.S. Department of Agriculture, Forest Service, General Technical Report WO-12.

Belsky, A.J, A. Matzke, and S. Uselman. 1999. Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States. Journal of Soil and Water Conservation 54(1):419-431.

Blaustein, A.R., D.G. Hokit, R.K. O'Hara and R.A. Holt. 1994. Pathogenic Fungus Contributes to Amphibian Losses in the Pacific Northwest. Biological Conservation 67(3):251-254.

Bobzien, S., and J.E. DiDonato. 2007. The Status of the California Tiger Salamander (*Ambystoma californiense*), California Red-Legged Frog (*Rana draytonii*), Foothill Yellow-Legged Frog (*Rana boylii*), and Other Aquatic Herpetofauna in the East Bay Regional Park District, California. Unpublished report. East Bay Regional Park District, Oakland, CA.

Bondi, C.A., S.M. Yarnell, and A.J. Lind. 2013. Transferability of Habitat Suitability Criteria for a Stream Breeding Frog (*Rana boylii*) in the Sierra Nevada, California. Herpetological Conservation and Biology 8(1):88-103.

Bourque, R.M. 2008. Spatial Ecology of an Inland Population of the Foothill Yellow-Legged Frog (*Rana boylii*) in Tehama County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Bourque, R.M., and J.B. Bettaso. 2011. *Rana boylii* (Foothill Yellow-legged Frogs). Reproduction. Herpetological Review 42(4):589.

Brattstrom, B.H. 1962. Thermal Control of Aggregation Behavior in Tadpoles. Herpetologica 18(1):38-46.

Breedvelt, K.G.H., and M.J. Ellis. 2018. Foothill Yellow-legged Frog (*Rana boylii*) Growth, Longevity, and Population Dynamics from a 9-Year Photographic Capture-Recapture Study. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Brehme, C.S., S.A. Hathaway, and R.N. Fisher. 2018. An Objective Road Risk Assessment Method for Multiple Species: Ranking 166 Reptiles and Amphibians in California. Landscape Ecology 33:911-935. DOI: 10.1007/s10980-018-0640-1

Brode, J.M., and R.B. Bury. 1984. The Importance of Riparian Systems to Amphibians and Reptiles. Pp. 30-36 *In* R. E. Warner and K. M. Hendrix (Editors). Proceedings of the California Riparian Systems Conference, University of California, Davis.

Bursey, C.R., S.R. Goldberg, and J.B. Bettaso. 2010. Persistence and Stability of the Component Helminth Community of the Foothill Yellow-Legged Frog, *Rana boylii* (Ranidae), from Humboldt County, California, 1964–1965, Versus 2004–2007. The American Midland Naturalist 163(2):476-482. https://doi.org/10.1674/0003-0031-163.2.476

Burton, C.A., T.M. Hoefen, G.S. Plumlee, K.L. Baumberger, A.R. Backlin, E. Gallegos, and R.N. Fisher. 2016. Trace Elements in Stormflow, Ash, and Burned Soil Following the 2009 Station Fire in Southern California. PLoS ONE 11(5):e0153372. DOI: 10.1371/journal.pone.0153372

Bury, R.B. 1972. The Effects of Diesel Fuel on a Stream Fauna. California Department of Fish and Game Bulletin 58:291-295.

Bury, R.B., and N.R. Sisk. 1997. Amphibians and Reptiles of the Cow Creek Watershed in the BLM-Roseburg District. Draft report submitted to BLM-Roseburg District and Oregon Department of Fish and Wildlife-Roseburg. Biological Resources Division, USGS, Corvallis, OR.

Butsic, V., and J.C. Brenner. 2016. Cannabis (*Cannabis sativa* or *C. indica*) Agriculture and the Environment: A Systematic, Spacially-explicit Survey and Potential Impacts. Environmental Research Letters 11(4):044023.

California Department of Fish and Wildlife [CDFW]. 2018a. Considerations for Conserving the Foothill Yellow-Legged Frog. California Department of Fish and Wildlife; 5/14/2018. http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=157562

California Department of Fish and Wildlife [CDFW]. 2018b. Green Diamond Resource Company Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-026-01. Northern Region, Eureka, CA.

California Department of Fish and Wildlife [CDFW]. 2018c. Humboldt Redwood Company Foothill Yellow-legged Frog Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-039-01. Northern Region, Eureka, CA.

California Department of Food and Agriculture [CDFA]. 2018. California Grape Acreage Report, 2017 Summary.
https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Acreage/2018/201804grpacSUMMARY.pdf

California Department of Forestry and Fire Protection [CAL FIRE]. 2019. Top 20 Largest California Wildfires. http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf

California Department of Pesticide Regulation [CDPR]. 2018. The Top 100 Sites Used by Pounds of Active Ingredients Statewide in 2016 (All Pesticides Combined).
https://www.cdpr.ca.gov/docs/pur/pur16rep/top_100_sites_lbs_2016.pdf

California Department of Water Resources [CDWR]. 2016. Drought and Water Year 2016: Hot and Dry Conditions Continue. 2016 California Drought Update.

California Natural Resources Agency [CNRA]. 2016. Safeguarding California: Implementation Action Plan. California Natural Resources Agency.
http://resources.ca.gov/docs/climate/safeguarding/Safeguarding%20California-Implementation%20Action%20Plans.pdf

California Secretary of State [CSOS]. 2016. Proposition 64 Marijuana Legalization Initiative Statute, Analysis by the Legislative Analyst.

California Water Commission [CWC]. 2019. Proposition 1 Water Storage Investment Program: Funding the Public Benefits of Water Storage Projects. Website accessed April 5, 2019 at https://cwc.ca.gov/Water-Storage

Carah, J.K., J.K. Howard, S.E. Thompson, A.G. Short Gianotti, S.D. Bauer, S.M. Carlson, D.N. Dralle, M.W. Gabriel, L.L. Hulette, B.J. Johnson, C.A. Knight, S.J. Kupferberg, S.L. Martin, R.L. Naylor, and M.E. Power. 2015. High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization. BioScience 65(8):822-829. DOI: 10.1093/biosci/biv083

Case, M.J., J.J. Lawler, and J.A. Tomasevic. 2015. Relative Sensitivity to Climate Change of Species in Northwestern North America. Biological Conservation 187:127-133.

Catenazzi, A., and S.J. Kupferberg. 2013. The Importance of Thermal Conditions to Recruitment Success in Stream-Breeding Frog Populations Distributed Across a Productivity Gradient. Biological Conservation 168:40-48.

Catenazzi, A., and S.J. Kupferberg. 2017. Variation in Thermal Niche of a Declining River-breeding Frog: From Counter-Gradient Responses to Population Distribution Patterns. Freshwater Biology 62:1255-1265.

Catenazzi, A., and S.J. Kupferberg. 2018. Consequences of Dam-Altered Thermal Regimes for a Riverine Herbivore's Digestive Efficiency, Growth and Vulnerability to Predation. Freshwater Biology 63(9):1037-1048. DOI: 10.1111/fwb.13112

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent Changes Towards Earlier Springs: Early Signs of Climate Warming in Western North America? Watershed Management Council Networker (Spring):3-7.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate Change Scenarios for the California Region. Climatic Change 87 (Supplement 1):21-42. DOI: 10.1007/s10584-007-9377-6

Climate Change Science Program [CCSP]. 2008. Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. *In* T.R. Karl, G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (Editors). Department of Commerce, NOAA's National Climate Data Center, Washington, DC.

Conlon, J.M., A. Sonnevend, M. Patel, C. Davidson, P.F. Nielsen, T. Pál, and L.A. Rollins-Smith. 2003. Isolation of Peptides of the Brevinin-1 Family with Potent Candidacidal Activity from the Skin Secretions of the Frog *Rana boylii*. The Journal of Peptide Research 62:207-213.

Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains. Science Advances 1(1):e1400082. DOI: 10.1126/sciadv.1400082

Cook, D.G., S. White, and P. White. 2012. *Rana boylii* (Foothill Yellow-legged Frog) Upland Movement. Herpetological Review 43(2):325-326.

Cordone, A.J., and D.W. Kelley. 1961. The Influence of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game 47(2):189-228.

Crayon, J.J. 1998. *Rana catesbeiana* (Bullfrog). Diet. Herpetological Review 29(4):232.

Davidson, C. 2004. Declining Downwind: Amphibian Population Declines in California and Historical Pesticide Use. Ecological Applications 14(6):1892-1902.

Davidson, C., H.B. Shaffer, and M.R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B, and Climate-Change Hypotheses for California Amphibian Declines. Conservation Biology 16(6):1588-1601.

Davidson, C., M.F. Benard, H.B. Shaffer, J.M. Parker, C. O'Leary, J.M. Conlon, and L.A. Rollins-Smith. 2007. Effects of Chytrid and Carbaryl Exposure on Survival, Growth and Skin Peptide Defenses in Foothill Yellow-legged Frogs. Environmental Science and Technology 41(5):1771-1776. DOI: 10.1021/es0611947

Dawson, T.P., S.T. Jackson, J.I. House, I.C. Prentice, and G.M. Mace. 2011. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science 332:53-58.

Dettinger, M., H. Alpert, J. Battles, J. Kusel, H. Safford, D. Fougeres, C. Knight, L. Miller, and S. Sawyer. 2018. Sierra Nevada Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004.

Dever, J.A. 2007. Fine-scale Genetic Structure in the Threatened Foothill Yellow-legged Frog (*Rana boylii*). Journal of Herpetology 41(1):168-173.

Dillingham, C.P., C.W. Koppl, J.E. Drennan, S.J. Kupferberg, A.J. Lind, C.S. Silver, T.V. Hopkins, K.D. Wiseman, and K.R. Marlow. 2018. *In Situ* Population Enhancement of an At-Risk Population of Foothill Yellow-legged Frogs, *Rana boylii*, in the North Fork Feather River, Butte County, California. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Doubledee, R.A., E.B. Muller, and R.M. Nisbet. 2003. Bullfrogs, Disturbance Regimes, and the Persistence of California Red-legged Frogs. Journal of Wildlife Management 67(2):424-438.

Drennan, J.E., K.A. Marlow, K.D. Wiseman, R.E. Jackman, I.A. Chan, and J.L. Lessard. 2015. *Rana boylii* Aging: A Growing Concern. Abstract of paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 8-10 January 2015, Malibu, CA.

Drost, C.A., and G.M. Fellers. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. Conservation Biology 10(2):414-425.

East Contra Costa County Habitat Conservancy [ECCCHC]. 2018. East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan Annual Report 2017.

Ecoclub Amphibian Group, K.L. Pope, G.M. Wengert, J.E. Foley, D.T. Ashton, and R.G. Botzler. 2016. Citizen Scientists Monitor a Deadly Fungus Threatening Amphibian Communities in Northern Coastal California, USA. Journal of Wildlife Diseases 52(3):516-523.

El Dorado Irrigation District [EID]. 2007. Project 184 Foothill Yellow-legged Frog Monitoring Plan.

Electric Consumers Protection Act [ECPA]. 1986. 16 United States Code § 797, 803.

Eriksson A., F. Elías-Wolff, B. Mehlig, and A. Manica. 2014. The Emergence of the Rescue Effect from Explicit Within- and Between-Patch Dynamics in a Metapopulation. Proceedings of the Royal Society B 281:20133127. http://dx.doi.org/10.1098/rspb.2013.3127

Evenden, F.G., Jr. 1948. Food Habitats of *Triturus granulosus* in Western Oregon. Copeia 1948(3):219-220.

Fahrig, L., and G. Merriam. 1985. Habitat Patch Connectivity and Population Survival. Ecology 66(6):1762-1768.

Federal Energy Regulatory Commission [FERC]. 2007a. Order Issuing New License, Project No. 233-081.

Federal Energy Regulatory Commission [FERC]. 2007b. Relicensing Settlement Agreement for the Upper American River Project and Chili Bar Hydroelectric Project.

Federal Energy Regulatory Commission [FERC]. 2009a. Order Amending Forest Service 4(e) Condition 5A, Project No. 1962-187.

Federal Energy Regulatory Commission [FERC]. 2009b. Order Issuing New License, Project No. 2130-033.

Federal Energy Regulatory Commission [FERC]. 2014. Order Issuing New License, Project No. 2101-084.

Federal Energy Regulatory Commission [FERC]. 2018. Final Environmental Impact Statement. Lassen Lodge Hydroelectric Project. Project No. 12496-002.

Federal Energy Regulatory Commission [FERC]. 2019. Active Licenses. FERC eLibrary. Accessed March 10, 2019. https://www.ferc.gov/industries/hydropower/gen-info/licensing/active-licenses.xls

Fellers, G.M. 2005. *Rana boylii* Baird, 1854(b). Pp. 534-536 *In* M. Lannoo (Editor). Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.

Ferguson, E. 2019. Cultivating Cooperation: Pilot Study Around Headwaters of Mattole River Considers the Effect of Legal Cannabis Cultivators on Northern California Watersheds. Outdoor California 79(1):22-29.

Fidenci, P. 2006. *Rana boylii* (Foothill Yellow-legged Frog) Predation. Herpetological Review 37(2):208.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting Climate Change in California. Ecological Impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, MA, and the Ecological Society of America, Washington, DC.

Fisher, R.N., and H.B. Shaffer. 1996. The Decline of Amphibians in California's Great Central Valley. Conservation Biology 10(5):1387-1397.

Fitch, H.S. 1936. Amphibians and Reptiles of the Rogue River Basin, Oregon. The American Midland Naturalist 17(3):634-652.

Fitch, H.S. 1938. *Rana boylii* in Oregon. Copeia 1938(3):148.

Fitch, H.S. 1941. The Feeding Habits of California Garter Snakes. California Fish and Game 27(2):1-32.

Florsheim, J.L., A. Chin, A.M. Kinoshita, and S. Nourbakhshbeidokhti. 2017. Effect of Storms During Drought on Post-Wildfire Recovery of Channel Sediment Dynamics and Habitat in the Southern California Chaparral, USA. Earth Surface Processes and Landforms 42(1):1482-1492. DOI: 10.1002/esp.4117.

Foe, C.G., and B. Croyle. 1998. Mercury Concentration and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary. Staff report, California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone Hazards to Amphibians and Reptiles. Herpetological Review 25(4):150-153, 156.

Fox, W. 1952. Notes on the Feeding Habits of Pacific Coast Garter Snakes. Herpetologica 8(1):4-8.

Fuller, D.D., and A.J. Lind. 1992. Implications of Fish Habitat Improvement Structures for Other Stream Vertebrates. Pp. 96-104 *In* Proceedings of the Symposium on Biodiversity of Northwestern California. R. Harris and D. Erman (Editors). Santa Rosa, CA.

Fuller, T.E., K.L. Pope, D.T. Ashton, and H.H. Welsh. 2011. Linking the Distribution of an Invasive Amphibian (*Rana catesbeiana*) to Habitat Conditions in a Managed River System in Northern California. Restoration Ecology 19(201):204-213. DOI: 10.1111/j.1526-100X.2010.00708.x

Furey, P.C., S.J. Kupferberg, and A.J. Lind. 2014. The Perils of Unpalatable Periphyton: *Didymosphenia* and Other Mucilaginous Stalked Diatoms as Food for Tadpoles. Diatom Research 29(3):267-280.

Gaos, A., and M. Bogan. 2001. A Direct Observation Survey of the Lower Rubicon River. California Department of Fish and Game, Rancho Cordova, CA.

Garcia and Associates [GANDA]. 2008. Identifying Microclimatic and Water Flow Triggers Associated with Breeding Activities of a Foothill Yellow-Legged Frog (*Rana boylii*) Population on the North Fork Feather River, California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-041.

Garcia and Associates [GANDA]. 2017. 2016 Surveys for Foothill Yellow-legged Frog El Dorado County, California for the El Dorado Hydroelectric Project (FERC No. 184) – Job 642-9. Prepared for El Dorado Irrigation District, San Francisco, CA.

Garcia and Associates [GANDA]. 2018. Draft Results of 2017 Surveys for Foothill Yellow-legged Frog (*Rana boylii*) on the Cresta and Poe Reaches of the North Fork Feather River – Job 708/145. Prepared for Pacific Gas and Electric Company, San Francisco, CA.

Geisseler, D., and W.R. Horwath. 2016. Grapevine Production in California. A collaboration between the California Department of Food and Agriculture; Fertilization Education and Research, Project; and University of California, Davis.
https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Grapevine_Production_CA.pdf

Gibbs, J.P., and A.R. Breisch. 2001. Climate Warming and Calling Phenology of Frogs Near Ithaca, New York, 1900-1999. Conservation Biology 15(4):1175-1178.

Gomulkiewicz, R., and R.D. Holt. 1995. When Does Evolution by Natural Selection Prevent Extinction? Evolution 49(1):201-207.

Gonsolin, T.T. 2010. Ecology of Foothill Yellow-legged Frogs in Upper Coyote Creek, Santa Clara County, CA. Master's Thesis. San Jose State University, San Jose, CA.

Grantham, T. E., A. M. Merenlender, and V. H. Resh. 2010. Climatic Influences and Anthropogenic Stressors: An Integrated Framework for Stream Flow Management in Mediterranean-climate California, U.S.A. Freshwater Biology 55(Supplement 1):188-204. DOI: 10.1111/j.1365-2427.2009.02379.x

Green, D.M. 1986a. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Karyological Evidence. Systematic Zoology 35(3):273-282.

Green, D.M. 1986b. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Electrophoretic Evidence. Systematic Zoology 35(3):283-296.

Green Diamond Resource Company [GDRC]. 2018. Mad River Foothill Yellow-legged Frog Egg Mass Surveys Summary Humboldt County, California. Progress report to the California Department of Fish and Wildlife, Wildlife Branch-Nongame Wildlife Program, pursuant to the requirements of Scientific Collecting Permit Entity #6348.

Griffin, D., and K.J. Anchukaitis. 2014. How Unusual is the 2012-2014 California Drought? Geophysical Research Letters 41: 9017-9023. DOI: 10.1002/2014GL062433.

Grinnell, J., and T. I. Storer. 1924. Animal Life in the Yosemite: An Account of the Mammals, Birds, Reptiles, and Amphibians in a Cross-section of the Sierra Nevada. University of California Press, Berkeley, CA.

Grinnell, J., J. Dixon, and J.M. Linsdale. 1930. Vertebrate Natural History of a Section of Northern California Through the Lassen Peak Region. University of California Press, Berkeley, CA.

Haggarty, M. 2006. Habitat Differentiation and Resource Use Among Different Age Classes of Post Metamorphic *Rana boylii* on Red Bank Creek, Tehama County, California. Master’s Thesis. Humboldt State University, Arcata, CA.

Harvey, B.C., and T.E. Lisle. 1998. Effects of Suction Dredging on Streams: A Review and an Evaluation Strategy. Fisheries 23(8):8-17.

Hayes, M.P., and M.R. Jennings. 1986. Decline of Ranid Frog Species in Western North America: Are Bullfrogs (*Rana catesbeiana*) Responsible? Journal of Herpetology 20(4):490-509.

Hayes, M.P., and M.R. Jennings. 1988. Habitat Correlates of Distribution of the California Red-legged Frog (*Rana aurora draytonii*) and the Foothill Yellow-Legged Frog (*Rana boylii*): Implications for Management. Pp. 144-158 *In* Management of Amphibians, Reptiles, and Small Mammals in North America, General Technical Report. RM-166 R.C. Szaro, K.E. Severson, and D.R. Patton (Technical Coordinators). USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hayes, M.P., C.A. Wheeler, A.J. Lind, G.A. Green, and D.C. Macfarlane (Technical Coordinators). 2016. Foothill Yellow-Legged Frog Conservation Assessment in California. Gen. Tech. Rep. PSW-GTR-248. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffle, and A. Vonk. 2003. Atrazine-induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence. Environmental Health Perspectives 11(4):568-575.

Hayes, T.B., P. Case, S. Chui, D. Chung, C. Haeffele, K. Haston, M. Lee, V. P. Mai, Y. Marjuoa, J. Parker, and M. Tsui. 2006. Pesticide Mixtures, Endocrine Disruption, and Amphibian Declines: Are We Underestimating the Impact? Environmental Health Perspectives 114(Supplement 1):40-50.

Hemphill, D.V. 1952. The Vertebrate Fauna of the Boreal Areas of the Southern Yolla Bolly Mountains, California. PhD Dissertation. Oregon State University, Corvallis.

Hillis, D.M., and T.P. Wilcox. 2005. Phylogeny of the New World true frogs (*Rana*). Molecular Phylogenetics and Evolution 34:299-314.

Hoffmann, A.A., and C.M. Sgrò. 2011. Climate Change and Evolutionary Adaptation. Nature 470:479-485. https://www.nature.com/articles/nature09670

Hogan, S., and C. Zuber. 2012. North Fork American River 2012 Summary Report. California Department of Fish and Wildlife Heritage and Wild Trout Program, Rancho Cordova, CA.

Hopkins, G.R., S.S. French, and E.D. Brodie. 2013. Increased Frequency and Severity of Developmental Deformities in Rough-skinned Newt (*Taricha granulosa*) Embryos Exposed to Road Deicing Salts (NaCl & $MgCl_2$). Environmental Pollution 173:264-269. http://dx.doi.org/10.1016/j.envpol.2012.10.002

Hothem, R.L., A.M. Meckstroth, K.E. Wegner, M.R. Jennings, and J.J. Crayon. 2009. Diets of Three Species of Anurans from the Cache Creek Watershed, California, USA. Journal of Herpetology 43(2):275-283.

Hothem, R.L., M.R. Jennings, and J.J. Crayon. 2010. Mercury Contamination in Three Species of Anuran Amphibians from the Cache Creek Watershed, California, USA. Environmental Monitoring and Assessment 163:433-448. https://doi.org/10.1007/s10661-009-0847-3

Humboldt Redwoods Company [HRC]. 2015. Habitat Conservation Plan for the Properties of The Pacific Lumber Company, Scotia Pacific Holding Company, and Salmon Creek Corporation under the Ownership and Management of Humboldt Redwood Company, LLC, as of July 2008. Established February 1999, Revised 12 August 2015.

ICF International. 2012. Final Santa Clara Valley Habitat Plan. https://scv-habitatagency.org/178/Santa-Clara-Valley-Habitat-Plan

Jackman, R.E., J.E. Drennan, K.R. Marlow, and K.D. Wiseman. 2004. Some Effects of Spring and Summer Pulse Flows on River-breeding Foothill Yellow-legged Frogs (*Rana boylii*) along the North Fork Feather

River. Abstract of paper presented at the Cal-Neva and Humboldt Chapters of the American Fisheries Society Annual Meeting 23 April 2004, Redding, CA.

Jennings, M.R., and M.P. Hayes. 1985. Pre-1900 Overharvest of California Red-Legged Frogs (*Rana aurora draytonii*): The Inducement for Bullfrog (*Rana catesbeiana*) Introduction. Herpetologica 41(1):94-103.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Contract No. 8023. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA.

Jennings, M.R., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Coloration. Herpetological Review 36(4):438.

Jones & Stokes Associates. 2006. East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan.

Karraker, N.E., J.P. Gibbs, and J.R. Vonesh. 2008. Impacts of Road Deicing Salt on the Demography of Vernal Pool-breeding Amphibians. Ecological Applications 18(3):724-734.

Kats, L.B., and R.P. Ferrer. 2003. Alien Predators and Amphibian Declines: Review of Two Decades of Science and the Transition to Conservation. Diversity and Distributions 9(2):99-110.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streambank Management Implications…A review. Journal of Range Management 37(5):430-437.

Kauffman, J.B., W.C. Krueger, and M. Varva. 1983. Impacts of Cattle on Streambanks in Northeastern Oregon. Journal of Range Management 36(6):683-685.

Keeley, J.E. 2005. Fire History of the San Francisco East Bay Region and Implications for Landscape Patterns. International Journal of Wildland Fire 14:285-296.

Keeley, J.E., and A.D. Syphard. 2016. Climate Change and Future Fire Regimes: Examples from California. Geosciences 6(7):37. DOI: 10.3390/geosciences6030037

Kerby, J.L., and A. Sih. 2015. Effects of Carbaryl on Species Interactions of the Foothill Yellow Legged Frog (*Rana boylii*) and the Pacific Treefrog (*Pseudacris regilla*). Hydrobiologia 746(1):255-269. DOI: 10.1007/s10750-014-2137-5

Kiesecker, J.M. 2002. Synergism Between Trematode Infection and Pesticide Exposure: A Link to Amphibian Limb Deformities in Nature? PNAS 99(15):9900-9904. https://doi.org/10.1073/pnas.152098899

Kiesecker, J.M., and A.R. Blaustein. 1997. Influences of Egg Laying Behavior on Pathogenic Infection of Amphibian Eggs. Conservation Biology 11(1):214-220.

Knowles, N., M.D. Dettinger, and D.R. Cayan. 2006. Trends in Snowfall Versus Rainfall in the Western United States. Journal of Climate 19(18):4545-4559. https://doi.org/10.1175/JCLI3850.1

Kupferberg, S.J. 1996a. Hydrologic and Geomorphic Factors Affecting Conservation of a River-Breeding Frog (*Rana boylii*). Ecological Applications 6(4):1322-1344.

Kupferberg, S.J. 1996b. The Ecology of Native Tadpoles (*Rana boylii* and *Hyla regilla*) and the Impact of Invading Bullfrogs (*Rana catesbeiana*) in a Northern California River. PhD Dissertation. University of California, Berkeley.

Kupferberg, S.J. 1997a. Bullfrog (*Rana catesbeiana*) Invasion of a California River: The Role of Larval Competition. Ecology 78(6):1736-1751.

Kupferberg, S.J. 1997b. The Role of Larval Diet in Anuran Metamorphosis. American Zoology 37:146-159.

Kupferberg, S., and A. Catenazzi. 2019. Between Bedrock and a Hard Place: Riverine Frogs Navigate Tradeoffs of Pool Permanency and Disease Risk During Drought. Abstract prepared for the Joint Meeting of Ichthyologists and Herpetologists. 24-28 July 2019, Snowbird, UT.

Kupferberg, S.J., A. Catenazzi, K. Lunde, A. Lind, and W. Palen. 2009a. Parasitic Copepod (*Lernaea cyprinacea*) Outbreaks in Foothill Yellow-legged Frogs (*Rana boylii*) Linked to Unusually Warm Summers and Amphibian Malformations in Northern California. Copeia 2009(3):529-537.

Kupferberg, S.J., A. Catenazzi, and M.E. Power. 2011a. The Importance of Water Temperature and Algal Assemblage for Frog Conservation in Northern California Rivers with Hydroelectric Projects. Final Report to the California Energy Commission, PIER. CEC-500-2014-033.

Kupferberg, S.J., and P.C. Furey. 2015. An Independent Impact Analysis using Carnegie State Vehicular Recreation Area Habitat Monitoring System Data. Friends of Tesla Park Technical Memorandum. DOI: 10.13140/RG.2.1.4898.9207

Kupferberg, S.J., A. Lind, J. Mount, and S. Yarnell. 2009b. Pulsed Flow Effects on the Foothill Yellow-Legged Frog (*Rana boylii*): Integration of Empirical, Experimental, and Hydrodynamic Modeling Approaches. Final Report. California Energy Commission, PIER. CEC-500-2009-002.

Kupferberg, S.J, A.J. Lind, and W.J. Palen. 2009c. Pulsed Flow Effects on the Foothill Yellow-legged Frog (*Rana boylii*): Population Modeling. Final Report to the California Energy Commission, PIER. CEC-500-2009-002a.

Kupferberg, S.J., A.J. Lind, V. Thill, and S.M. Yarnell. 2011b. Water Velocity Tolerance in Tadpoles of the Foothill Yellow-legged Frog (*Rana boylii*): Swimming Performance, Growth, and Survival. Copeia 2011(1):141-152.

Kupferberg, S.J., W.J. Palen, A.J. Lind, S. Bobzien, A. Catenazzi, J. Drennan, and M.E. Power. 2012. Effects of Flow Regimes Altered by Dams on Survival, Population Declines, and Range-wide Losses of California River-Breeding Frogs. Conservation Biology 26(3):513-524.

Lambert, M.R., T. Tran, A. Kilian, T. Ezaz, and D.K. Skelly. 2019. Molecular Evidence for Sex Reversal in Wild populations of Green Frogs (*Rana clamitans*). PeerJ 7:e6449. DOI: 10.7717/peerj.6449

Lande, R., and S. Shannon. 1996. The Role of Genetic Variation in Adaptation and Population Persistence in a Changing Environment. Evolution 50(1):434-437.

Leidy, R.A., E. Gonsolin, and G.A. Leidy. 2009. Late-summer Aggregation of the Foothill Yellow-legged Frog (*Rana boylii*) in Central California. The Southwestern Naturalist 54(3):367-368.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, and J.N. Seiber. 1999. Summertime Transport of Current-Use Pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. Environmental Toxicology and Chemistry 18(12):2715-2722.

Lind, A.J. 2005. Reintroduction of a Declining Amphibian: Determining an Ecologically Feasible Approach for the Foothill Yellow-legged Frog (*Rana boylii*) Through Analysis of Decline Factors, Genetic Structure, and Habitat Associations. PhD Dissertation. University of California, Davis.

Lind, A.J., J.B. Bettaso, and S.M. Yarnell. 2003a. Natural History Notes: *Rana boylii* (Foothill Yellow-legged Frog) and *Rana catesbeiana* (Bullfrog). Reproductive behavior. Herpetological Review 34(3):234-235.

Lind, A.J., L. Conway, H. (Eddinger) Sanders, P. Strand, and T. Tharalson. 2003b. Distribution, Relative Abundance, and Habitat of Foothill Yellow-legged Frogs (*Rana boylii*) on National Forests in the Southern Sierra Nevada Mountains of California. Report to the FHR Program of Region 5 of the USDA Forest Service.

Lind, A.J., P.Q. Spinks, G.M. Fellers, and H.B. Shaffer. 2011. Rangewide Phylogeography and Landscape Genetics of the Western U.S. Endemic Frog *Rana boylii* (Ranidae): Implications for the Conservation of Frogs and Rivers. Conservation Genetics 12:269-284.

Lind, A.J., and H.H. Welsh, Jr. 1994. Ontogenetic Changes in Foraging Behaviour and Habitat Use by the Oregon Garter Snake, *Thamnophis atratus hydrophilus*. Animal Behaviour 48:1261-1273.

Lind, A.J., H.H. Welsh, Jr., and C.A. Wheeler. 2016. Foothill Yellow-legged Frog (*Rana boylii*) Oviposition Site Choice at Multiple Spatial Scales. Journal of Herpetology 50(2):263-270.

Lind, A.J., H.H. Welsh, Jr., and R.A. Wilson. 1996. The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii*) in Northwestern California. Herpetological Review 27(2):62-67.

Little, E.E., and R.D. Calfee. 2000. The Effects of UVB Radiation on the Toxicity of Fire-Fighting Chemicals. Final Report. U.S. Geological Service, Columbia Environmental Research Center, Columbia, MO.

Loomis, R.B. 1965. The Yellow-legged Frog, *Rana boylei*, from the Sierra San Pedro Mártir, Baja California Norte, México. Herpetologica 21(1):78-80.

Lowe, J. 2009. Amphibian Chytrid (*Batrachochytrium dendrobatidis*) in Postmetamorphic *Rana boylii* in Inner Coast Ranges of Central California. Herpetological Review 40(2):180.

Macey, R.J., J.L. Strasburg, J.A. Brisson, V.T. Vredenburg, M. Jennings, and A. Larson. 2001. Molecular Phylogenetics of Western North American Frogs of the *Rana boylii* Species Group. Molecular Phylogenetics and Evolution 19(1):131-143.

MacTague, L., and P.T. Northen. 1993. Underwater Vocalization by the Foothill Yellow-Legged Frog (*Rana boylii*). Transactions of the Western Section of the Wildlife Society 29:1-7.

Mallakpour, I., M. Sadegh, and A. AghaKouchak. 2018. A New Normal for Streamflow in California in a Warming Climate: Wetter Wet Seasons and Drier Dry Seasons. Journal of Hydrology 567:203-211.

Mallery, M. 2010. Marijuana National Forest: Encroachment on California Public Lands for Cannabis Cultivation. Berkeley Undergrad Journal 23(2):1-50. http://escholarship.org/uc/item/7r10t66s#page-2

Marlow, C.B., and T.M. Pogacnik. 1985. Time of Grazing and Cattle-Induced Damage to Streambanks. Pp. 279-284 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Marlow, K.R., K.D. Wiseman, C.A. Wheeler, J.E. Drennan, and R.E. Jackman. 2016. Identification of Individual Foothill Yellow-legged Frogs (*Rana boylii*) using Chin Pattern Photographs: A Non-Invasive and Effective Method for Small Population Studies. Herpetological Review 47(2):193-198.

Martin, C. 1940. A New Snake and Two Frogs for Yosemite National Park. Yosemite Nature Notes 19(11):83-85.

Martin, P.L., R.E. Goodhue, and B.D. Wright. 2018. Introduction. Pp. 1-25 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California.
https://s.giannini.ucop.edu/uploads/giannini_public/07/5c/075c8120-3705-4a79-ae74-130fdfe46c6b/introduction.pdf

McCartney-Melstad, E., M. Gidiş, and H.B. Shaffer. 2018. Population Genomic Data Reveal Extreme Geographic Subdivision and Novel Conservation Actions for the Declining Foothill Yellow-legged Frog. Heredity 121:112-125.

Megahan, W.F., J.G. King, and K.A. Seyedbagheri. 1995. Hydrologic and Erosional Responses of a Granitic Watershed to Helicopter Logging and Broadcast Burning. Forest Science 41(4):777-795.

Merenlender, A.M. 2000. Mapping Vineyard Expansion Provides Information on Agriculture and the Environment. California Agriculture 54(3):7-12.

Mierau, D.W., W.J. Trush, G.J. Rossi, J.K. Carah, M.O. Clifford, and J.K. Howard. 2017. Managing Diversions in Unregulated Streams using a Modified Percent-of-Flow Approach. Freshwater Biology 63:752-768. DOI: 10.1111/fwb.12985

Moyle, P.B. 1973. Effects of Introduced Bullfrogs, *Rana catesbeiana*, on the Native Frogs of the San Joaquin Valley, California. Copeia 1973(1):18-22.

Moyle, P.B., and P.J. Randall. 1998. Evaluating the Biotic Integrity of Watersheds in the Sierra Nevada, California. Conservation Biology 12(6):1318-1326.

Napa County. 2010. Napa County Voluntary Oak Woodlands Management Plan.

National Integrated Drought Information System [NIDIS]. 2019. Drought in California from 2000-2019. National Drought Mitigation Center, U.S. Department of Agriculture Federal Drought Assistance. Accessed 25 April 2019 at https://www.drought.gov/drought/states/california

National Marine Fisheries Service [NMFS]. 2012. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office, Sacramento, CA.

National Marine Fisheries Service [NMFS]. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, CA.

Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians & Reptiles of the Pacific Northwest. University Press of Idaho, Moscow, ID.

Off-Highway Motor Vehicle Recreation Commission [OHMVRC]. 2017. Off-Highway Motor Vehicle Recreation Commission Program Report, January 2017. http://ohv.parks.ca.gov/pages/1140/files/OHMVR-Commission-2017-Program_Report-FINAL-Mar2017_web.pdf

Office of Environmental Health Hazard Assessment [OEHAA], California Environmental Protection Agency. 2018. Indicators of Climate Change in California. https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

Olson, D.H., and R. Davis. 2009. Conservation Assessment for the Foothill Yellow-legged Frog (*Rana boylii*) in Oregon. USDA Forest Service Region 6 and USDI Bureau of Land Management Interagency Special Status Species Program.

Olson, E.O., J.D. Shedd, and T.N. Engstrom. 2016. A Field Inventory and Collections Summary of Herpetofauna from the Sutter Buttes, an "Inland Island" within California's Great Central Valley. Western North American Naturalist 76(3):352-366.

Pacific Gas and Electric [PG&E]. 2018. Pit 3, 4, and 5 Hydroelectric Project (FERC Project No. 233) Foothill Yellow-Legged Frog Monitoring 2017 Annual Report.

Padgett-Flohr, G.E., and R.L. Hopkins. 2009. *Batrachochytrium dendrobatidis*, a Novel Pathogen Approaching Endemism in Central California. Diseases of Aquatic Organisms 83:1-9.

Palstra, F.P., and D.E. Ruzzante. 2008. Genetic Estimates of Contemporary Effective Population Size: What Can They Tell Us about the Importance of Genetic Stochasticity for Wild Population Persistence? Molecular Ecology 17:3428-3447. DOI: 10.1111/j.1365-294X.2008.03842.x

Paoletti, D.J., D.H. Olson, and A.R. Blaustein. 2011. Responses of Foothill Yellow-legged Frog (*Rana boylii*) Larvae to an Introduced Predator. Copeia 2011(1):161-168.

Parks, S.A., C. Miller, J.T. Abatzoglou, L.M. Holsinger, M-A. Parisien, and S.Z. Dobrowski. 2016. How Will Climate Change Affect Wildland Fire Severity in the Western US? Environmental Research Letters 11:035002. DOI: 10.1088/1748-9326/11/3/035002

Parmesan, C., and G. Yohe. 2003. A Globally Coherent Fingerprint of Climate Change Impacts across Natural Systems. Nature 421(6918):37-42. DOI: 10.1038/nature01286

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs Call at a Higher Pitch in Traffic Noise. Ecology and Society 12(1):25. http://www.ecologyandsociety.org/vol14/iss1/art25/

Peek, R.A. 2011. Landscape Genetics of Foothill Yellow-legged Frogs (*Rana boylii*) in Regulated and Unregulated Rivers: Assessing Connectivity and Genetic Fragmentation. Master's Thesis. University of San Francisco, San Francisco, CA.

Peek, R.A. 2018. Population Genetics of a Sentinel Stream-breeding Frog (*Rana boylii*). PhD Dissertation. University of California, Davis.

Peek, R., and S. Kupferberg. 2016. Assessing the Need for Endangered Species Act Protection of the Foothill Yellow-legged Frog (*Rana boylii*): What do Breeding Censuses Indicate? Abstract of poster presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 7-8 January 2016, Davis, CA.

Pilliod, D.S., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and Amphibians in North America. Forest Ecology and Management 178:163-181.

Placer County Water Agency [PCWA]. 2008. Final AQ 12 – Special-Status Amphibian and Aquatic Reptile Technical Study Report – 2007. Placer County Water Agency Middle Fork American River Project (FERC No. 2079), Auburn, CA.

Pounds, A., A.C.O.Q. Carnaval, and S. Corn. 2007. Climate Change, Biodiversity Loss, and Amphibian Declines. Pp. 19-20 *In* C. Gascon, J.P. Collins, R.D. Moore, D.R. Church, J.E. McKay, and J.R. Mendelson III (Editors). IUCN Amphibian Conservation Action Plan, Proceedings: IUCN/SSC Amphibian Conservation Summit 2005.

Powell, R., R. Conant, and J.T. Collins. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central America, Fourth Edition.

Power, M.E., M.S. Parker, and W.E. Dietrich. 2008. Seasonal Reassembly of a River Food Web: Floods, Droughts, and Impacts of Fish. Ecological Monographs 78(2):263-282.

Prado, M. 2005. Rare Frogs Put at Risk by Visitors in West Marin. Marin Independent Journal. Newspaper article, May 09, 2005.

Public Policy Institute of California [PPIC]. 2018. Storing Water. https://www.ppic.org/publication/californias-water-storing-water/

Public Policy Institute of California [PPIC]. 2019. California's Future: Population. https://www.ppic.org/wp-content/uploads/californias-future-population-january-2019.pdf

Radeloff, V.C., D.P. Helmers, H.A. Kramer, M.H. Mockrin, P.M. Alexandre, A. Bar-Massada, V. Butsic, T.J. Hawbaker, S. Martinuzzi, A.D. Syphard, and S.I. Stewart. 2018. Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk. PNAS 115(13):3314-3319. https://doi.org/10.1073/pnas.1718850115

Railsback, S.F., B.C. Harvey, S.J. Kupferberg, M.M. Lang, S. McBain, and H.H. Welsh, Jr. 2016. Modeling Potential River Management Conflicts between Frogs and Salmonids. Canadian Journal of Fisheries and Aquatic Sciences 73:773-784.

Reeder, N.M.M., A.P. Pessier, and V.T. Vredenburg. 2012. A Reservoir Species for the Emerging Amphibian Pathogen *Batrachochytrium dendrobatidis* Thrives in a Landscape Decimated by Disease. PLoS ONE 7(3):e33567. https://doi.org/10.1371/journal.pone.0033567

Riegel, J.A. 1959. The Systematics and Distribution of Crayfishes in California. California Fish and Game 45:29-50.

Relyea, R.A. 2005. The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Ecological Applications 15(2):618-627.

Relyea, R.A., and N. Diecks. 2008. An Unforeseen Chain of Events: Lethal Effects of Pesticides on Frogs at Sublethal Concentrations. Ecological Applications 18(7):1728-1742.

Rombough, C. 2006. Winter Habitat Use by Juvenile Foothill Yellow-legged Frogs (*Rana boylii*): The Importance of Seeps. *In* Abstracts from the 2006 Annual Meetings of the Society for Northwestern Vertebrate Biology and the Washington Chapter of the Wildlife Society. Northwest Naturalist 87(2):159.

Rombough, C.J., J. Chastain, A.M. Schwab, and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(4):438-439.

Rombough, C.J., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation: Eggs and Hatchlings. Herpetological Review 36(2):163-164.

Rombough, C.J., and M.P. Hayes. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Reproduction. Herpetological Review 38(1):70-71.

Russell, K.R., D.H. Van Lear, and D.C. Guynn, Jr. 1999. Prescribed Fire Effects on Herpetofauna: Review and Management Implications. Wildlife Society Bulletin 27(2):374-384.

San Joaquin Council of Governments, Inc. [SJCOG 2018]. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2018 Annual Report.

San Joaquin County. 2000. San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan.

Santa Clara Valley Habitat Agency [SCVHA]. 2019. Santa Clara Valley Habitat Plan 4th Annual Report FY2017-2018.

Scheele, B.C., F. Pasmans, L.F. Skerratt, L. Berger, A. Martel, W. Beukema, A.A. Acevedo, P.A. Burrows, T. Carvalhos, A. Catenazzi, I. De la Riva, M.C. Fisher, S.V. Flechas, C.N. Foster, P. Frías-Álvarez, T.W.J. Garner, B. Gratwicke, J.M. Guayasamin, M. Hirschfeld, J.E. Kolby, T.A. Kosch, E. La Marca, D.B. Lindenmayer, K.R. Lips, A.V. Longo, R. Maneyro, C.A. McDonald, J. Mendelson III, P. Palacios-Rodriguez, G. Parra-Olea, C.L. Richards-Zawacki, M-O. Rödel, S.M. Rovito, C. Soto-Azat, L.F. Toledo, J. Voyles, C. Weldon, S.M. Whitfield, M. Wilkinson, K.R. Zamudio, and S. Canessa. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. Science 363(6434):1459-1463. DOI: 10.1126/science.aav0379

Siekert, R.E., Q.D. Skinner, M.A. Smith, J.L. Dodd, and J.D. Rogers. 1985. Channel Response of an Ephemeral Stream in Wyoming to Selected Grazing Treatments. Pp. 276-278 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Silver, C.S. 2017. Population-level Variation in Vocalizations of *Rana boylii*, the Foothill Yellow-legged Frog. Master's Thesis. California State University, Chico, Chico, CA.

Snover, M.L., and M.J. Adams. 2016. Herpetological Monitoring and Assessment on the Trinity River, Trinity County, California-Final Report: U.S. Geological Survey Open-File Report 2016-1089. http://dx.doi.org/10.3133/ofr20161089

Sparling, D.W., and G.M. Fellers. 2007. Comparative Toxicity of Chlorpyrifos, Diazinon, Malathion and Their Oxon Derivatives to *Rana boylii*. Environmental Pollution 147:535-539.

Sparling, D.W., and G.M. Fellers. 2009. Toxicity of Two Insecticides to California, USA, Anurans and Its Relevance to Declining Amphibian Populations. Environmental Toxicology and Chemistry 28(8):1696-1703.

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and Amphibian Declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.

Spencer, C.N., and F.R. Hauer. 1991. Phosphorus and Nitrogen Dynamics in Streams During a Wildfire. Journal of the North American Benthological Society 10(1):24-30.

Spring Rivers Ecological Sciences. 2003. Foothill Yellow-legged Frog (*Rana boylii*) Studies in 2002 for Pacific Gas and Electric Company's Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233). Pacific Gas and Electric Company, Technical and Ecological Services, San Ramon, CA.

State Board of Forestry and Fire Protection [SBFFP]. 2018. 2018 Strategic Fire Plan for California. Accessed March 1, 2019 at: http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf1614.pdf

State Water Resources Control Board [SWRCB]. 2017. Water Quality Certification for the Pacific Gas and Electric Company Poe Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2107.

State Water Resources Control Board [SWRCB]. 2018. Water Quality Certification for the South Feather Water and Power Agency South Feather Power Project, Federal Energy Regulatory Commission Project No. 2088.

State Water Resources Control Board [SWRCB]. 2019. February 2019 Executive Director's Report. Accessed February 18, 2019 at: https://www.waterboards.ca.gov/board_info/exec_dir_rpts/2019/ed_rpt_021119.pdf

Stebbins, R.C. 2003. Peterson Filed Guides Western Reptiles and Amphibians. Third Edition. Houghton Mifflin Company, Boston, MA.

Stebbins, R.C., and S.M. McGinnis. 2012. Field Guide to Amphibians and Reptiles of California. Revised Edition. University of California Press, Berkeley, CA.

Stephens, S.L., N. Burrows, A. Buyantuyev, R.W. Gray, R.E. Keane, R. Kubian, S. Liu, F. Seijo, L. Shu, K.G. Tolhurst, and J.W. van Wagtendonk. 2014. Temperate and Boreal Forest Mega-Fires: Characteristics and Challenges. Frontiers in Ecology and the Environment 12(2):115-122.

Stephens, S.L, J.D. McIver, R.E.J. Boerner, C.J. Fettig, J.B. Fontaine, B.R. Hartsough, P.I. Kennedy, and D.W. Schwilk. 2012. The Effects of Forest Fuel-Reduction Treatments in the United States. BioScience 62(6):549-560.

Stewart, I.T. 2009. Changes in Snowpack and Snowmelt Runoff for Key Mountain Regions. Hydrological Processes 23:78-94. DOI: 10.1002/hyp.7128

Stillwater Sciences. 2012. Analysis of Long-term River Regulation Effects on Genetic Connectivity of Foothill Yellow-legged Frogs (*Rana boylii*) in the Alameda Creek Watershed. Final Report. Prepared by Stillwater Sciences, Berkeley, CA for SFPUC, San Francisco, CA.

Stopper, G.F., L. Hecker, R.A. Franssen, and S.K. Sessions. 2002. How Trematodes Cause Limb Deformities in Amphibians. Journal of Experimental Zoology Part B (Molecular and Developmental Evolution) 294:252-263.

Storer, T.I. 1923. Coastal Range of Yellow-legged Frog in California. Copeia 114:8.

Storer, T.I. 1925. A Synopsis of the Amphibia of California. University of California Publication Zoology 27:1-342.

Sweet, S.S. 1983. Mechanics of a Natural Extinction Event: *Rana boylii* in Southern California. Abstract of paper presented at the Joint Annual Meeting of the Herpetologists' League and Society for the Study of Amphibians and Reptiles 7-12 August 1983, Salt Lake City, UT.

Syphard, A.D., V.C. Radeloff, T.J. Hawbaker, and S.I. Stewart. 2009. Conservation Threats Due to Human-Caused Increases in Fire Frequency in Mediterranean-Climate Ecosystems. Conservation Biology 23(3):758–769. DOI: 10.1111/j.1523-1739.2009.01223.x

Syphard, A.D., V.C. Radeloff, J.E. Keeley, T.J. Hawbaker, M.K. Clayton, S.I. Stewart, and R.B. Hammer. 2007. Human Influence on California Fire Regimes. Ecological Applications 17(5):1388-1402.

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573.

Thompson, C., R. Sweitzer, M. Gabriel, K. Purcell, R. Barrett, and R. Poppenga. 2014. Impacts of Rodenticide and Insecticide Toxicants from Marijuana Cultivation Sites on Fisher Survival Rates in the Sierra National Forest, California. Conservation Letters 7(2):91-102.

Thomson, R.C., A.N. Wright, and H.B. Shaffer. 2016. California Amphibian and Reptile Species of Special Concern. University of California Press, Berkeley, CA.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

Tracey, J.A., C.J. Rochester, S.A. Hathaway, K.L. Preston, A.D. Syphard, A.G. Vandergast, J.E. Diffendorfer, J. Franklin, J.B. MacKenzie, T.A. Oberbauer, S. Tremor, C.S. Winchell, and R.N. Fisher. 2018. Prioritizing Conserved Areas Threatened by Wildfire and Fragmentation for Monitoring and Management. PLoS ONE 13(9):e0200203. https://doi.org/10.1371/journal.pone.0200203

Troïanowski, M., N. Mondy, A. Dumet, C. Arcajo, and T. Lengagne. 2017. Effects of Traffic Noise on Tree Frog Stress Levels, Immunity, and Color Signaling. Conservation Biology 31(5):1132-1140.

Twitty, V.C., D. Grant, and O. Anderson. 1967. Amphibian Orientation: An Unexpected Observation. Science 155(3760):352-353.

Unrine, J.M., C.H. Jagoe, W.A. Hopkins, and H.A. Brant. 2004. Adverse Effects of Ecologically Relevant Dietary Mercury Exposure in Southern Leopard Frog (*Rana sphenocephala*) Larvae. Environmental Toxicology and Chemistry 23(12):2964-2970.

U.S. Fish and Wildlife Service [USFWS]. 1998. Recovery Plan for the Shasta Crayfish (*Pacifastacus fortis*). U.S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service [USFWS]. 2015. Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions. Federal Register 80(126):37568-37579.

U.S. Fish and Wildlife Service [USFWS] and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report. U.S. Fish and Wildlife Service, Arcata, CA.

U.S. Forest Service [USFS]. 2004. Sierra Nevada Forest Plan Amendment. Final Supplemental Environmental Impact Statement, Record of Decision.

U.S. Forest Service [USFS] and Bureau of Land Management [BLM]. 1994. Standards and guidelines for management of habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl.

Van Wagner, T.J. 1996. Selected Life-History and Ecological Aspects of a Population of Foothill Yellow-legged Frogs (*Rana boylii*) from Clear Creek, Nevada County, California. Master's Thesis. California State University Chico, Chico, CA.

Volpe, R.J., III, R. Green, D. Heien, and R. Howitt. 2010. Wine-Grape Production Trends Reflect Evolving Consumer Demand over 30 Years. California Agriculture 64(1):42-46.

Wang, I.J., J.C. Brenner, and V. Bustic. 2017. Cannabis, an Emerging Agricultural Crop, Leads to Deforestation and Fragmentation. Frontiers in Ecology and the Environment 15(9):495-501. DOI: 10.1002/fee.1634

Warren, D.L., A.N. Wright, S.N. Seifert, and H.B. Shaffer. 2014. Incorporating Model Complexity and Spatial Sampling Bias into Ecological Niche Models of Climate Change Risks Faced by 90 California Vertebrate Species of Concern. Diversity and Distributions 20:334-343. DOI: 10.1111/ddi.12160

Welsh, H.H., Jr., and G.R. Hodgson. 2011. Spatial Relationships in a Dendritic Network: The Herpetofaunal Metacommunity of the Mattole River Catchment of Northwest California. Ecography 34:49-66. DOI: 10.1111/j.1600-0587.2010.06123.x

Welsh, H.H., Jr., G.R. Hodgson, and A.J. Lind. 2005. Ecography of the Herpetofauna of a Northern California Watershed: Linking Species Patterson to Landscape Processes. Ecography 23:521-536.

Welsh, H.H., Jr., and L.M. Ollivier. 1998. Stream Amphibians as Indicators of Ecosystem Stress: A Case Study from California's Redwoods. Ecological Applications 8(4):1118-1132.

Werschkul, D.F., and M.T. Christensen. 1977. Differential Predation by *Lepomis macrochirus* on the Eggs and Tadpoles of *Rana*. Herpetologica 33(2):237-241.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Science 313(5789):940-943. DOI: 10.1126/science.1128834

Wheeler, C.A., J.B. Bettaso, D.T. Ashton and H.H. Welsh, Jr. 2014. Effects of Water Temperature on Breeding Phenology, Growth, and Metamorphosis of Foothill Yellow-legged Frogs (*Rana boylii*): A Case Study of the Regulated Mainstem and Unregulated Tributaries of California's Trinity River. River Research and Applications 31:1276-1286. DOI: 10.1002/rra.2820

Wheeler, C.A., J.M. Garwood, and H.H. Welsh, Jr. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Physiological Skin Color Transformation. Herpetological Review 36(2):164-165.

Wheeler, C.A., A.J. Lind, H.H. Welsh, Jr., and A.K. Cummings. 2018. Factors that Influence the Timing of Calling and Oviposition of a Lotic Frog in Northwestern California. Journal of Herpetology 52(3):289-298.

Wheeler, C.A., and H.H. Welsh, Jr. 2008. Mating Strategy and Breeding Patterns of the Foothill Yellow-legged Frog (*Rana boylii*). Herpetological Conservation and Biology 3(2):128-142.

Wheeler, C.A., H.H. Welsh, Jr., and T. Roelofs. 2006. Oviposition Site Selection, Movement, and Spatial Ecology of the Foothill Yellow-legged Frog (*Rana boylii*). Final Report to the California Department of Fish and Game Contract No. P0385106, Sacramento, CA.

Williams, A.P., R. Seager, J.T. Abatzoglou, B.I. Cook, J.E. Smerdon, and E.R. Cook. 2015. Contribution of Anthropogenic Warming to California Drought During 2012–2014. Geophysical Research Letters 42:6819-6828. DOI: 10.1002/2015GL064924

Williams S.E., L.P. Shoo, J.L. Isaac, A.A. Hoffmann, and G. Langham. 2008. Towards an Integrated Framework for Assessing the Vulnerability of Species to Climate Change. PLoS Biol 6(12):e325. DOI: 10.1371/journal.pbio.0060325

Wiseman, K.D., and J. Bettaso. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Cannibalism and Predation. Herpetological Review 38(2):193.

Wiseman, K.D., K.R. Marlow, R.E. Jackman, and J.E. Drennan. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(2):162-163.

Wright, A.N., R.J. Hijmans, M.W. Schwartz, and H.B. Shaffer. 2013. California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change. Final Report to the California Department of Fish and Wildlife. Contract No. P0685904, Sacramento, CA.

Yap, T.A., M.S. Koo, R.F. Ambrose, and V.T. Vredenburg. 2018. Introduced Bullfrog Facilitates Pathogen Invasion in the Western United States. PLoS ONE 13(4):e0188384. https://doi.org/10.1371/journal.pone.0188384

Yarnell, S.M. 2005. Spatial Heterogeneity of *Rana boylii* Habitat: Physical Properties, Quantification and Ecological Meaningfulness. PhD Dissertation. University of California, Davis.

Yarnell, S.M., J.H. Viers, and J.F. Mount. 2010. Ecology and Management of the Spring Snowmelt Recession. Bioscience 60(2):114-127.

Yoon, J-H., S-Y.S. Wang, R.R. Gillies, B. Kravitz, L. Hipps, and P.J. Rasch. 2015. Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle under Global Warming. Nature Communications 6:8657. DOI: 10.1038/ncomms9657

Young, C.A., M. Escobar, M. Fernandes, B. Joyce, M. Kiparsky, J.F. Mount, V. Mehta, J.H. Viers, and D. Yates. 2009. Modeling the Hydrology of California's Sierra Nevada for Sub-Watershed Scale Adaptation to Climate Change. Journal of American Water Resources Association 45:1409-1423.

Zhang, H., C. Cai, W. Fang, J. Wang, Y. Zhang, J. Liu, and X. Jia. 2013. Oxidative Damage and Apoptosis Induced by Microcystin-LR in the Liver of *Rana nigromaculata* in Vivo. Aquatic Toxicology 140-141:11-18.

Zillioux, E.J., D.B. Porcella, and J.M. Benoit. 1993. Mercury Cycling and Effects in Freshwater Wetland Ecosystems. Environmental Toxicology and Chemistry 12:2245-2264.

Zweifel, R.G. 1955. Ecology, Distribution, and Systematics of Frogs of the *Rana boylei* Group. University of California Publications in Zoology 54(4):207-292.

Zweifel, R.G. 1968. *Rana boylii* Baird, Foothill Yellow-legged Frog. Catalogue of American Amphibians and Reptiles. Pp. 71.1-71.2.

Personal Communications

Alvarez, J. 2017. The Wildlife Project. Email to the Department.

Alvarez, J. 2018. The Wildlife Project. Letter to Tom Eakin, Peter Michael Winery, provided to the Department.

Anderson, D.G. 2017. Redwood National Park. Foothill Yellow-legged Frog (*Rana boylii*) Survey of Redwood Creek on August 28, 2017, Mainstem Redwood Creek, Redwood National Park, Humboldt County, California.

Ashton, D. 2017. U.S. Geological Survey. Email response to Department solicitation for information.

Blanchard, K. 2018. California Department of Fish and Wildlife. Email response to Department solicitation for information.

Bourque, R. 2018. California Department of Fish and Wildlife. Email.

Bourque, R. 2019. California Department of Fish and Wildlife. Internal review comments.

Chinnichi, S. 2017. Humboldt Redwood Company. Email response to the Department solicitation for information.

Grefsrud, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Hamm, K. 2017. Green Diamond Resource Company. Email response to the Department solicitation for information.

Kundargi, K., 2014. California Department of Fish and Wildlife. Internal memo.

Kupferberg, S. 2018. UC Berkeley. Spreadsheet of Eel River egg mass survey results.

Kupferberg, S. 2019. UC Berkeley. Spreadsheet of breeding censuses and clutch density plots by river.

Kupferberg, S., and A. Lind. 2017. UC Berkeley and U.S. Forest Service. Draft recommendation for best management practices to the Department's North Central Region.

Kupferberg, S., and R. Peek. 2018. UC Davis and UC Berkeley. Email to the Department.

Kupferberg, S., R. Peek, and A. Catenazzi. 2015. UC Berkeley, UC Davis, and Southern Illinois University Carbondale. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., and M. Power. 2015. UC Berkeley. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., M. van Hattem, and W. Stokes. 2017. UC Berkeley and California Department of Fish and Wildlife. Email about lower flows in the South Fork Eel River and upstream cannabis.

Rose, T. 2014. Wildlife Photographer. Photographs of river otters consuming Foothill Yellow-legged Frogs on the Eel River.

Smith, J. 2015. San Jose State University. Frog and Turtle Studies on Upper Coyote Creek for (2010-2015; cumulative report).

Smith, J. 2016. San Jose State University. Upper Coyote Creek Stream Survey Report – 20 April 2016.

Smith, J. 2017. San Jose State University. Upper Llagas Creek Fish Resources in Response to the Recent Drought, Fire, and Extreme Wet Winter, 8 October 2017.

Sweet, S. 2017. University of California Santa Barbara. Email to the Department.

van Hattem, M. 2018. California Department of Fish and Wildlife. Telephone call.

van Hattem, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Weiss, K. 2018. California Department of Fish and Wildlife. Email.

Geographic Information System Data Sources

Amphibian and Reptile Species of Special Concern [ARSSC]. 2012. Museum Dataset.

Biological Information Observation System [BIOS]. Aquatic Organisms [ds193]; Aquatic Ecotoxicology - Whiskeytown NRA 2002-2003 [ds199]; North American Herpetological Education and Research Project (HERP) - Gov [ds1127]; and Electric Power Plants - California Energy Commission [ds2650].

California Department of Fish and Wildlife [CDFW]. Various Unpublished Foothill Yellow-legged Frog Observations from 2009 through 2018.

California Department of Food and Agriculture [CDFA]. Temporary Licenses Issued for Commercial Cannabis Cultivation, January 2019 version.

California Department of Forestry [CAL FIRE]. 2017 Fire Perimeters and 2018 Supplement.

California Department of Water Resources [DWR]. 2000. Dams under the Jurisdiction of the Division of Safety and Dams.

California Military Department [CMD]. Camp Roberts Boundary.

California Natural Diversity Database [CNDDB]. February 2019 version.

California Protected Areas Database [CPAD]. Public Lands, 2017 version.

California Wildlife Habitat Relationships [CWHR]. 2014 Range Map Modified to Include the Sutter Buttes.

Electronic Water Rights Information Management System [eWRIMS]. Points of Diversion - State Water Resources Control Board, 2019 version.

Facility Registry Service [FRS]. Power Plants Operated by the Army Corps of Engineers – U.S. Environmental Protection Agency Facility Registry Service, 2014 version.

Humboldt Redwood Company [HRC]. Incidental Foothill Yellow-legged Frog Observations from 1995 to 2018.

Mendocino Redwoods Company [MRC]. Foothill Yellow-legged Frog Egg Mass Survey Results from 2017 and 2018.

National Hydrography Dataset [NHD]. Watershed Boundary Dataset, 2018 version.

PRISM Climate Group [PRISM]. Annual Average Precipitation for 2012 through 2016; and the 30 Year Average from 1980-2010.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

U.S. Bureau of Land Management [BLM]. Tribal Lands - Bureau of Indian Affairs Surface Management, 2014 version.

U.S. Department of Defense [DOD]. Military Lands Boundaries in California.

Patterson, Laura@Wildlife

From: Ryan Peek <rapeek@ucdavis.edu>
Sent: Tuesday, June 18, 2019 12:52 AM
To: Patterson, Laura@Wildlife
Subject: Re: Peer Review Request: Foothill Yellow-legged Frog Status Review
Attachments: DRAFT FYLF Status Review-RAP.docx

Hi Laura,
Attached is my review of the draft FYLF status report. I'm sending this now because I leave tomorrow at 6am for about 9 days on the Yampa/Green River, so will be completely out of contact. If you have questions/concerns, I can follow up then. Overall, this is a really amazing compendium of all the research/knowledge about RABO, so kudos to you for all your hard work! It shows...this was simultaneously really cool to read (because after all this time I still really am fascinated by this species and always interested in learning more), and very depressing. I hope folks recognize just how dire things look for this species across much of the range. Most of my comments are pretty minor (hopefully) and I added an updated figure and a few citations you may want to check out or add.

I'll touch base when I get back.

Adios,
Ryan

On Tue, May 21, 2019 at 1:56 PM Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov> wrote:

> Good afternoon, Dr. Peek,
>
> Thanks for your patience. We had a couple of loose ends to tie up. Please see the attached letter and draft status review. If you have any questions or concerns with the timeline, please let me know.
>
> Will you please respond to this email to confirm you received it?
>
> Thanks again,
>
> Laura
>
> **From:** Ryan Peek <rapeek@ucdavis.edu>
> **Sent:** Thursday, April 25, 2019 5:05 PM
> **To:** Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov>
> **Subject:** Re: Peer Review Request: Foothill Yellow-legged Frog Status Review

Hi Laura,

I would be willing to review the draft status review, and I have no financial or other conflicts of interest.

Thanks very much,

Adios,
Ryan

On Thu, Apr 25, 2019 at 9:04 AM Patterson, Laura@Wildlife <Laura.Patterson@wildlife.ca.gov> wrote:

Dear Dr. Peek,

The Fish and Game Commission (Commission) was petitioned to list the Foothill Yellow-legged Frog as threatened under the California Endangered Species Act (CESA) by the Center for Biological Diversity in December 2016. The California Department of Fish and Wildlife (Department) is tasked with writing a status review and providing a recommendation to the Commission on whether or not the best scientific information available supports the petitioner's position that listing is warranted. Part of the status review process is external peer review of the draft status review.

I am contacting you as a Foothill Yellow-legged Frog subject matter expert to request your participation in the peer review process. The Department expects the draft will be ready on for distribution to peer reviewers on or around May 17th. We would ask that you focus your review on the scientific information available regarding the status of Foothill Yellow-legged Frogs in California. Your peer review of the science and analysis regarding each of the listing factors prescribed in CESA (i.e., present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) is particularly valuable. We request that comments be submitted on or before one month from the date of receipt (on or around June 17th).

In addition, per the Department's Peer Review Policy (Department Bulletin 2017-03), I must ensure that you have no financial or other conflict of interest with the outcome or implications of the peer reviewed product.

Please respond to whether you are willing and able to participate in this important part of the listing determination process by Friday May 3rd.

Thank you for your consideration,

Laura

Laura Patterson
Statewide Amphibian and Reptile Conservation Coordinator
California Department of Fish and Wildlife
Nongame Wildlife Program
1812 9th Street
Sacramento, CA 95811
Please Help Endangered Species at Tax Time
https://www.wildlife.ca.gov/Tax-Donation

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"When we try to pick out anything by itself, we find it hitched to everything else in the universe."
John Muir (My First Summer in the Sierra, 1911)

Ryan Peek, PhD

Aquatic Ecologist, Post-Doctoral Researcher

Center for Watershed Sciences, UC Davis

ryanpeek.github.io

@riverpeek

530.754.5351

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STATE OF CALIFORNIA
NATURAL RESOURCES AGENCY
DEPARTMENT OF FISH AND WILDLIFE

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF THE **FOOTHILL YELLOW-LEGGED FROG** (*Rana boylii*) IN CALIFORNIA

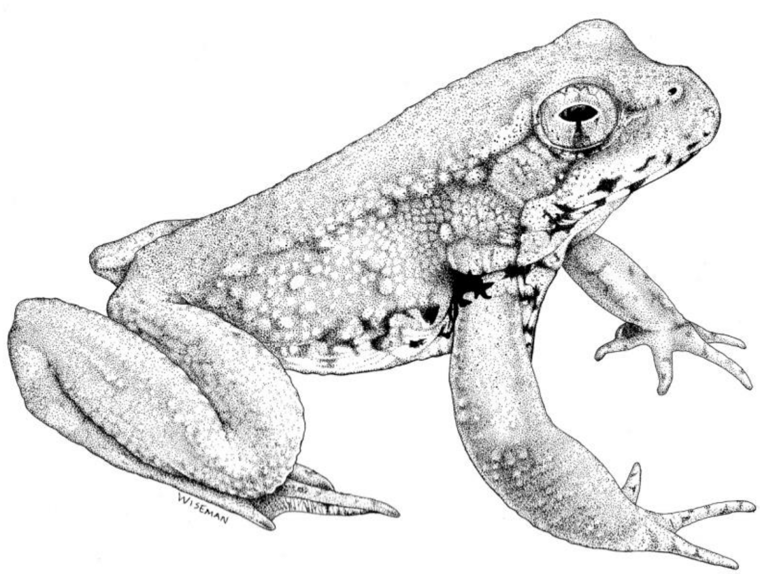
CHARLTON H. BONHAM, DIRECTOR
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
External Peer Review Draft

TABLE OF CONTENTS

LIST OF FIGURES

Commented [RAP1]: Pretty sure I made this figure in R, and this was part of the stuff Sarah and I did as part of the 2016 poster (Peek and Kupferberg). I don't care if it says Kupferberg and Peek or Peek and Kupferberg, but please add me to this figure when it's used.

LIST OF TABLES



ACKNOWLEDGMENTS

Laura Patterson prepared this report. Stephanie Hogan, Madeleine Wieland, and Margaret Mantor assisted with portions of the report, including the sections on Status and Trends in California and Existing Management. Kristi Cripe provided GIS analysis and figures. Review of a draft document was provided by the following California Department of Fish and Wildlife (Department) staff: Ryan Bourque, Marcia Grefsrud, and Mike van Hattem.

The Department is extremely grateful for the valuable comments provided on this report by the following peer reviewers: Dr. Sarah Kupferberg, Dr. Amy Lind, Dr. Jimmy McGuire, and Dr. Ryan Peek. The conclusions in this report are those of the Department and do not necessarily reflect those of the reviewers.

Cover photograph by Isaac Chellman, used with permission.

Illustration by Kevin Wiseman, used with permission.

EXECUTIVE SUMMARY

[To be completed after external peer review]

REGULATORY SETTING

Petition Evaluation Process

A petition to list the Foothill Yellow-legged Frog (*Rana boylii*) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on December 14, 2016 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on December 22, 2016 and published a formal notice of receipt of the petition on January 20, 2017 (Cal. Reg. Notice Register 2017, No. 3-Z, p. 46). A petition to list or delist a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3).

On April 17, 2017, the Department provided the Commission with its evaluation of the petition, "Evaluation of the Petition from the Center For Biological Diversity to List the Foothill Yellow-legged Frog (*Rana boylii*) as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on June 21, 2017, in Smith River, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Foothill Yellow-legged Frog was designated a candidate species on July 7, 2017 (Cal. Reg. Notice Register 2017, No. 27-Z, p. 986).

Status Review Overview

The Commission's action designating the Foothill Yellow-legged Frog as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 21, 2018, in Sacramento, California, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

This status review report is not intended to be an exhaustive review of all published scientific literature relevant to the Foothill Yellow-legged Frog; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to the Foothill Yellow-legged Frog. This review is intended to provide the Commission with the most current information on the Foothill Yellow-legged Frog and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The status review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

Federal Endangered Species Act Review

The Foothill Yellow-legged Frog is currently under review for possible listing as threatened or endangered under the federal Endangered Species Act (ESA) in response to a July 11, 2012 petition submitted by the Center for Biological Diversity. On July 1, 2015, the U.S. Fish and Wildlife Service (USFWS) published its 90-day finding that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted and initiated a status review of the species (USFWS 2015). On March 16, 2016, the Center for Biological Diversity sued the USFWS to compel issuance of a 12-month finding on whether listing under the ESA is warranted. On August 30, 2016, the parties reached a stipulated settlement agreement that the USFWS shall publish its 12-month finding in the Federal Register on or before September 30, 2020 (*Center for Biological Diversity v. S.M.R. Jewell* (D.D.C. Aug. 30, 2016, No. 16-CV-00503)).

BIOLOGY AND ECOLOGY

Species Description and Life History

> *"In its life-history* boylii *exhibits several striking specializations which are in all probability related to the requirements of life of a stream-dwelling species"* – Tracy I. Storer, 1925

The Foothill Yellow-legged Frog is a small- to medium-sized frog; adults range from 38 to 81 mm (1.5-3.2 in) snout to urostyle length (SUL) with females attaining a larger size than males and males possessing paired internal vocal sacs (Zweifel 1955, Nussbaum et al. 1983, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs are typically gray, brown, olive, or reddish with brown-black flecking and mottling, which generally matches the substrate of the stream in which they reside (Nussbaum et al. 1983, Stebbins and McGinnis 2012). They often have a pale triangle between the eyes and snout and broad dark bars on the hind legs (Zweifel 1955, Stebbins and McGinnis 2012). Foothill Yellow-legged Frogs have a relatively squat body and granular skin, giving them a rough appearance similar to a toad, and fully webbed feet with slightly expanded toe tips (Nussbaum et al. 1983). The tympanum is also rough

and relatively small compared to congeners at around one-half the diameter of the eye (Zweifel 1955). The dorsolateral folds (glandular ridges extending from the eye area to the rump) in Foothill Yellow-legged Frogs are indistinct compared to other western North American ranids (Stebbins and McGinnis 2012). Ventrally, the abdomen is white with variable amounts of dark mottling on the chest and throat, which are unique enough to be used to identify individuals (Marlow et al. 2016). As their name suggests, the underside of their hind limbs and lower abdomen are often yellow; however, individuals with orange and red have been observed within the range of the California Red-legged Frog (*Rana draytonii*), making hindlimb coloration a poor diagnostic characteristic for this species (Jennings and Hayes 2005).

Adult females likely lay one clutch of eggs per year and may breed every year (Storer 1925, Wheeler et al. 2006). Foothill Yellow-legged Frog egg masses resemble a compact cluster of grapes approximately 45 to 90 mm (1.8-3.5 in) in diameter length-wise and contain anywhere from around 100 to over 3,000 eggs (Kupferberg et al. 2009c, Hayes et al. 2016). The individual embryos are dark brown to black with a lighter area at the vegetative pole and surrounded by three jelly envelopes that range in diameter from approximately 3.9 to 6.0 mm (0.15-0.25 in) (Storer 1925, Zweifel 1955, Hayes et al. 2016).

Foothill Yellow-legged Frog tadpoles hatch out around 7.5 mm (0.3 in) long and are a dark brown or black (Storer 1925, Zweifel 1955). They grow rapidly to 37 to 56 mm (1.5-2.2 in) and turn olive with a coarse brown mottling above and an opaque silvery color below (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012). Their eyes are positioned dorsally when viewed from above (i.e., within the outline of the head), and their mouths are large, downward-oriented, and suction-like with several tooth rows (Storer 1925, Zweifel 1955, Stebbins and McGinnis 2012, Hayes et al. 2016). Foothill Yellow-legged Frogs metamorphose at around 14-17 mm (0.55-0.67 in) SUL (Fellers 2005). Sexual maturity is attained at around 30-40 mm (1.2-1.6 in) SUL and 1 year for males and around 40-50 mm (1.6-2.0 in) SUL and 3 years for females, although in some populations this has been accelerated by a year (Zweifel 1955, Kupferberg et al. 2009c, Breedveld and Ellis 2018). During the breeding season, males can be distinguished from females by the presence of nuptial pads (swollen darkened thumb bases that aid in holding females during amplexus) and calling, which frequently occurs underwater but sometimes from the surface (MacTague and Northen 1993, Stebbins 2003, Silver 2017).

The reported lifespan of Foothill Yellow-legged Frogs varies widely by study. Storer (1925) and Van Wagner (1996) estimated a maximum age of 2 years for both sexes and the vast majority of the population. Breedveld and Ellis (2018) calculated the typical lifespan of males at 3-4 years and 5-6 years for females. Bourque (2008), using skeletochronology, found an individual over 7 years old and a mean age of 4.7 and 3.6 years for males and females, respectively. Drennan et al. (2015) estimated maximum age at 13 years for both sexes in a Sierra Nevada population and 12 for males and 11 for females in a Coast Range population.

Range and Distribution

Foothill Yellow-legged Frogs historically ranged from the Willamette River drainage in Oregon west of the Sierra-Cascade crest to at least the San Gabriel River drainage in Los Angeles County, California (Figure 1; Zweifel 1955, Stebbins 2003). In addition, a disjunct population was reported from 2,040 m

Figure 1. Foothill Yellow-legged Frog historical range (adapted from CWHR, Loomis [1965], Nussbaum et al. [1983])

Commented [RAP2]: Similarly the blip that extends into the east side near mono lake…I know that Bob Thomson mentioned some erroneous records they followed up on for the ARSSC report/book. This feels like it may be in the same vicinity. As drawn, it indicates RABO may have been in Tuolumne Meadows and down into Lee Vining Creek…which may be true I've just never read/heard that to be the case.

Commented [RAP3]: The population/records near Lassen (looks like near Last Chance Creek, etc) seem unlikely, but I could be convinced. Based on what Brad said, I'm a bit more dubious of records from that vicinity, not to mention that area is largely >6,000 ft in elevation.

(6,700 ft) in the Sierra San Pedro Mártir, Baja California Norte, México (Loomis 1965). In California, the species occupies foothill and mountain streams in the Klamath, Cascade, Sutter Buttes, Coast, Sierra Nevada, and Transverse ranges from sea level to 1,940 m (6,400 ft), but generally below 1,525 m (5,000 ft) (Hemphill 1952, Nussbaum et al. 1983, Stebbins 2003, Olson et al. 2016). Zweifel (1955) considered Foothill Yellow-legged Frogs to be present and abundant throughout their range where streams possessed suitable habitat.

Commented [RAP4]: See my comments on the map above…if this (or the more likely current value of 5,000 ft) is true, then some of the range highlighted is over that elevation limit…

Taxonomy and Phylogeny

Foothill Yellow-legged Frogs belong to the family Ranidae (true frogs), which inhabits every continent except Antarctica and contains more than 700 species (Stebbins 2003). The species was first described by Baird (1854) as *Rana boylii*. After substantial taxonomic uncertainty with respect to its relationship to other ranids (frogs in the family Ranidae) and several name changes over the next century, the Foothill Yellow-legged Frog (*R. boylii* with no subspecific epithet) was eventually recognized as a distinct species again by Zweifel (1955, 1968). The phylogenetic relationships among the western North American *Rana* spp. have been revised several times and are still not entirely resolved (Thomson et al. 2016). The Foothill Yellow-legged Frog was previously thought to be most closely related to the higher elevation Mountain Yellow-legged Frog (*R. muscosa*) (Zweifel 1955; Green 1986a,b). However, genetic analyses undertaken by Macey et al. (2001) and Hillis and Wilcox (2005) suggest they are more closely related to Oregon Spotted Frogs (*R. pretiosa*) and Columbia Spotted Frogs (*R. luteiventris*), respectively.

Commented [RAP5]: Can also add a more recent paper by Yuan et al. 2016 on Ranidae frog phylogeny which supports RABO as more closely related to Columbia spotted frogs (see figure 1 in paper).

Yuan, Z.-Y., Zhou, W.-W., Chen, X., Poyarkov, N. A., Jr, Chen, H.-M., Jang-Liaw, N.-H., … Che, J. (2016). Spatiotemporal diversification of the true frogs (Genus Rana): A historical framework for a widely studied group of model organisms. *Systematic Biology*, *65*(5), 824–842. https://doi.org/10.1093/sysbio/syw055

Population Structure and Genetic Diversity

Foothill Yellow-legged Frog populations exhibit varying levels of partitioning and genetic diversity at different spatial scales. At the coarse landscape level across the species' extant range, McCartney-Melstad et al. (2018) recovered five deeply divergent, geographically cohesive, genetic clades (Figure 2), while Peek (2018) recovered six (Figure 3). Genetic divergence is the process of speciation; it is a measure of the number of mutations accumulated by populations over time from a shared ancestor. This accumulation of genetic differentiation between groups is what ~~that~~ differentiates one population from another population ~~them from the other populations~~ in a species. When genetic divergence among ~~clades~~ groups with common ancestors (clades) is large enough, it can be used as a tool to define new species or subspecies.

The geographic breaks among the five Foothill Yellow-legged Frog clades were similar between the studies, but Peek (2018) identified a separate deeply divergent genetic clade in the Feather River watershed that is distinct from the rest of the northern Sierra Nevada clade. The five clades the two studies shared include the following [Note: naming conventions follow McCartney-Melstad et al. (2018) and Peek (2018)]:

(1) Northwest/North Coast: north of San Francisco Bay in the Coast Ranges and east into Tehama County;
(2) Northeast/Northern Sierra: northern El Dorado County (North Fork American River watershed, includes Middle Fork American) and north in the Sierra Nevada to southern Plumas County (Upper Yuba River watershed);

114 Evan McCartney-Melstad et al.

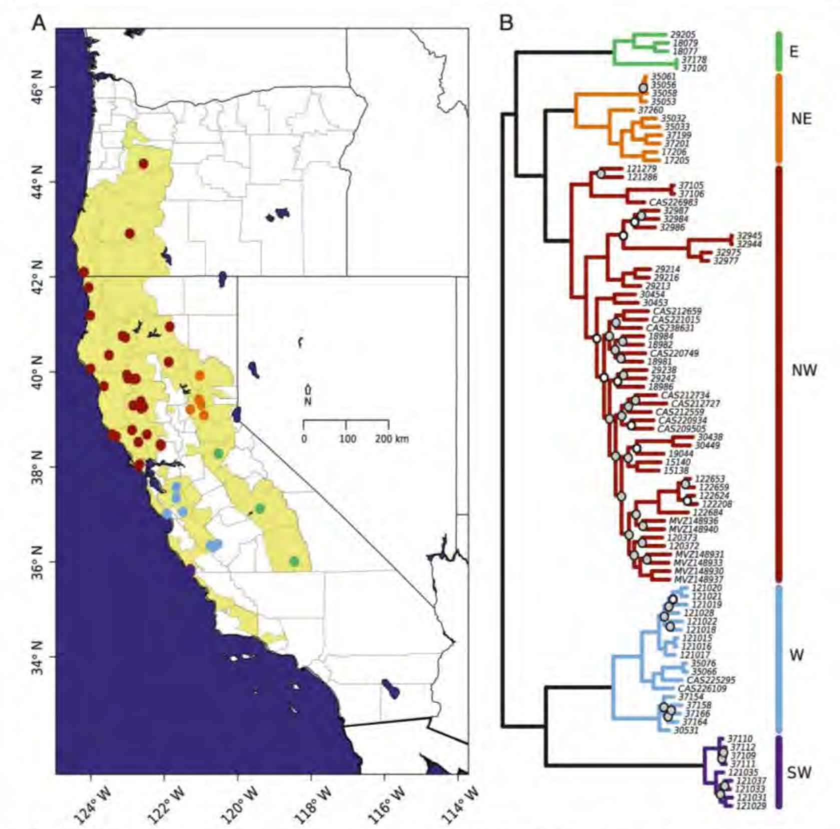


Fig. 1 **a** Map of *Rana boylii* sample localities. County outlines are shown within California and Oregon. Light yellow indicates the IUCN range map of *R. boylii*, excluding a small disjunct population at Sierra San Pedro Martir, Baja California, Mexico. Dots are colored by major grouping as determined in the **b** RAxML phylogeny, with midpoint rooting. Nodes without dots received >95% bootstrap support, those with white dots received <95% but greater than or equal to 75% bootstrap support, while nodes with gray dots received <75% bootstrap support

Figure 2. Foothill Yellow-legged Frog clades by McCartney-Melstad et al. (2018)

(3) East/Southern Sierra: El Dorado County (South Fork American River watershed) and south in the Sierra Nevada [no samples from Amador County were tested, but they would most likely fall within this clade because it is located between two other populations that occur within this clade];

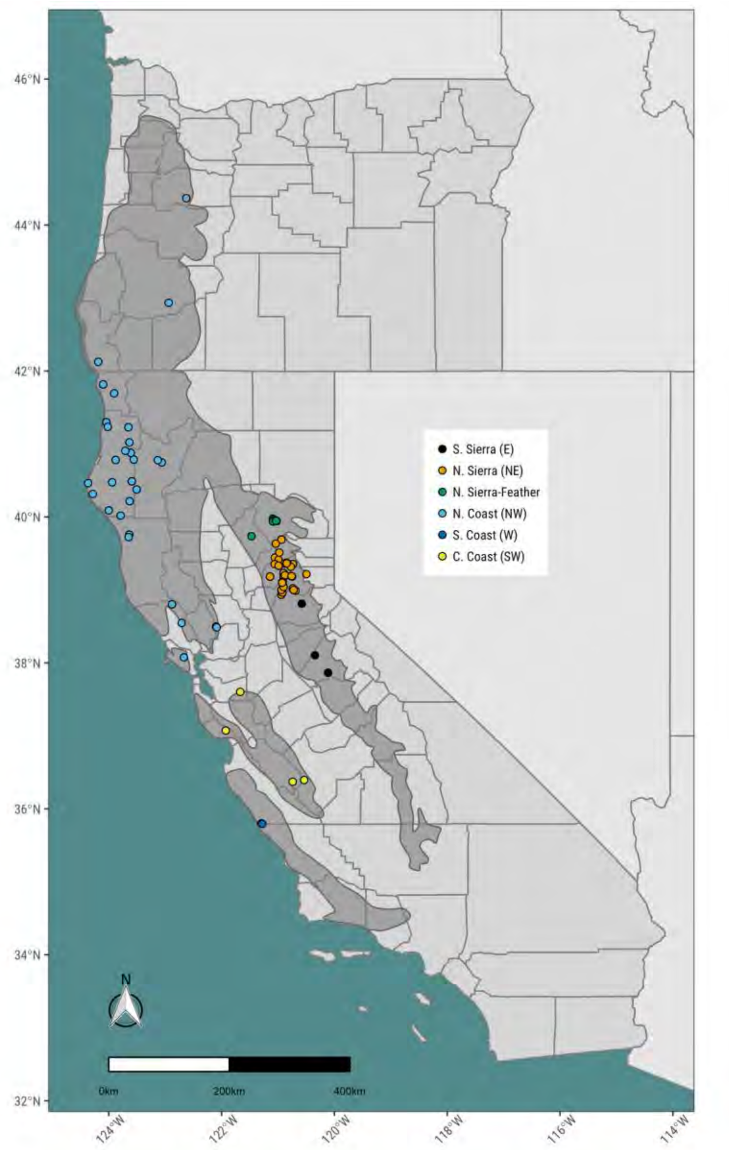


Figure 3. Foothill Yellow-legged Frog clades by Peek (2018)

Commented [RAP6]: This is an updated figure, feel free to email me if you want a higher res version, but I suspect this should do just fine.

(4) West/Central Coast: south of San Francisco Bay in the Coast Ranges to San Benito and Monterey counties, presumably east of the San Andreas Fault/Salinas Valley;
(5) Southwest/South Coast presumably west of the San Andreas Fault/Salinas Valley in Monterey County and south in the Coast Ranges.

The Feather River clade is found primarily in Plumas and Butte counties (Peek 2018). Peek's analysis found that this clade is as distinct ~~as~~from the other Sierra Nevada clades as the Sierra Nevada populations are distinct from ~~the rest of the Sierra Nevada as a cohesive group and~~ all the coastal ~~populations~~ clades~~as one group~~, meaning it was found to be deeply divergent from the rest of the clades. McCartney-Melstad et al. (2018) also recognized the Feather River watershed as distinct from the rest of the northern Sierra but not as deeply divergent from the other clades as Peek. The Feather River watershed is also the only known location where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs (*R. sierrae*) co-occur and where two F1 hybrids (50% ancestry from each species) were found (Peek 2018). In addition, Peek's genetic data provided ~~Peek~~weak support for ~~'s modeling results only weakly supported~~ dividing the West/Central Coast and Southwest/South Coast groups into separate clades, but had fewer samples from these localities than McCartney-Melstad et al.

Previous work conducted by Lind et al. (2011) found a somewhat similar pattern, that populations on the periphery of the species' range are considerably genetically divergent from the rest of the range. Their results suggested that hydrologic regions and river basins were important landscape features that influenced the genetic structure of Foothill Yellow-legged Frog populations. However, using more modern genomic techniques, McCartney-Melstad et al. (2018) found nearly twice the variation among the five phylogenetic clades than among drainage basins, indicating other factors contributed to current population structure. They report that the depth of genetic divergence among Foothill Yellow-legged Frog clades exceeds that of any anuran (frog or toad) for which similar data are available and recommend using them as management units instead of the previously suggested watershed boundaries.

Levels of genetic diversity within the clades differed significantly. Genetic diversity provides populations with the evolutionary capacity to adapt to changing conditions ~~gives species the ability to adapt to changing conditions~~ (i.e., evolve), and its loss often signals extreme population ~~and range~~ reductions as well as potential inbreeding depression that can reduce survival and reproductive success (Lande and Shannon 1996, Hoffmann and Sgrò 2011, McCartney-Melstad et al. 2018). Loss of genetic diversity in Foothill Yellow-legged Frogs largely follows a north-to-south pattern, with the southern clades in particular (Southwest/South Coast and East/Southern Sierra) showing the greatest loss of nucleotide diversity ~~possessing the least amount~~ (McCartney-Melstad et al. 2018, Peek 2018). In addition, these study results demonstrate that Foothill Yellow-legged Frogs have lost genetic diversity over time across their entire range except for the large Northwest/North Coast clade, which appears to have undergone a relatively recent population expansion (McCartney-Melstad et al. 2018, Peek 2018).

At a watershed scale, Dever (2007) found that tributaries to rivers and streams are important for preserving genetic diversity, and populations separated by more than 10 km (6.2 mi) show signs of genetic isolation. In other words, even in the absence of anthropogenic barriers to dispersal (e.g., dams and reservoirs), individuals located more than 10 km (6.2 mi) are not typically considered part of a single interbreeding population (Olson and Davis 2009). Peek (~~2011~~2010, 2018) reported that at this finer-scale, population structure and genetic diversity appear to be more strongly influenced by river regulation type (i.e., dammed or undammed) than to geographic distance or watershed boundaries. In general, regulated (dammed) rivers had limited gene flow and higher genetic divergence among subpopulations compared with unregulated (undammed) rivers (Peek ~~2011~~2010, 2018). In addition, differences in river hydrologic~~water flow~~ regimes within regulated rivers affected genetic connectivity and diversity (Peek ~~2011~~2010, 2018). Subpopulations in hydropeaking reaches, in which pulsed flows are used for electricity generation or whitewater boating, exhibited significantly lower gene flow and genetic diversity than those in bypass reaches where water is diverted from upstream in the basin down to power generating facilities (Figure 4; Peek 2018). River regulation had a greater influence on genetic differentiation among sites than geographic distance in the Alameda Creek watershed as well (Stillwater Sciences 2012). Reduced connectivity among sites leads to lower gene flow and a loss of genetic diversity through genetic drift, which can diminish adaptability to changing environmental conditions (Palstra and Ruzzante 2008). Peek (2011) posits that given the *R. boylii* species group is estimated to be 8 million years old (Macey et al. 2001), the significant reductions in connectivity and genetic diversity over short evolutionary time periods in regulated rivers (often less than 50 years from the time of dam construction) is cause for concern, particularly when combined with small population sizes.

Habitat Associations and Use

> *"These frogs are so closely restricted to streams that it is unusual to find one at a greater distance from the water than it could cover in one or two leaps."* – Richard G. Zweifel, 1955

Foothill Yellow-legged Frogs inhabit rivers and streams ranging from primarily rain-fed (coastal populations) to primarily snow-influenced (most Sierra Nevada and Klamath-Cascade populations) from headwater streams to large rivers (Bury and Sisk 1997, Wheeler et al. 2014). Occupied rivers and streams flow through a variety of vegetation types including hardwood, conifer, and valley-foothill riparian forests; mixed chaparral; and wet meadows (Hayes et al. 2016). Because the species is so widespread and can be found in so many types of habitats, the vegetation community is likely less important in determining Foothill Yellow-legged Frog occupancy and abundance than the aquatic biotic and abiotic conditions in the specific river, stream, or reach (Zweifel 1955). The species is an obligate stream-breeder, which sets it apart from other western North American ranids (Wheeler et al. 2014). Foothill Yellow-legged Frog habitat is generally characterized as partly-shaded, shallow, perennial rivers and streams with a low gradient and rocky substrate that is at least cobble-sized (Zweifel 1955, Hayes and Jennings 1988). However, the use of intermittent and ephemeral streams by post-metamorphic Foothill Yellow-legged Frogs may not be all that uncommon in some parts of the species' range in California (R. Bourque pers. comm. 2019). The species has been reported from some atypical habitats as well, including ponds, isolated pools in intermittent streams, and meadows along the edge of streams that lack a rocky substrate (Fitch 1938, Zweifel 1955, J. Alvarez pers. comm. 2017, CDFW 2018a).

As stream-breeding poikilotherms (animals whose internal temperature varies with ambient temperature), appropriate flow velocity, temperature, and water availability are critically important to

Foothill Yellow-legged Frogs (Kupferberg 1996a, Van Wagner 1996, Wheeler et al. 2006, Lind et al. 2016). Habitat quality is also influenced by hydrologic regime (regulated vs. unregulated), substrate, presence of non-native predators and competitors, water depth, and availability of high-quality food and basking sites (Lind et al. 1996, Yarnell 2005, Wheeler et al. 2006, Catenazzi and Kupferberg 2017). Habitat suitability and use vary by life stage, sex, geographic location, watershed size, and season and

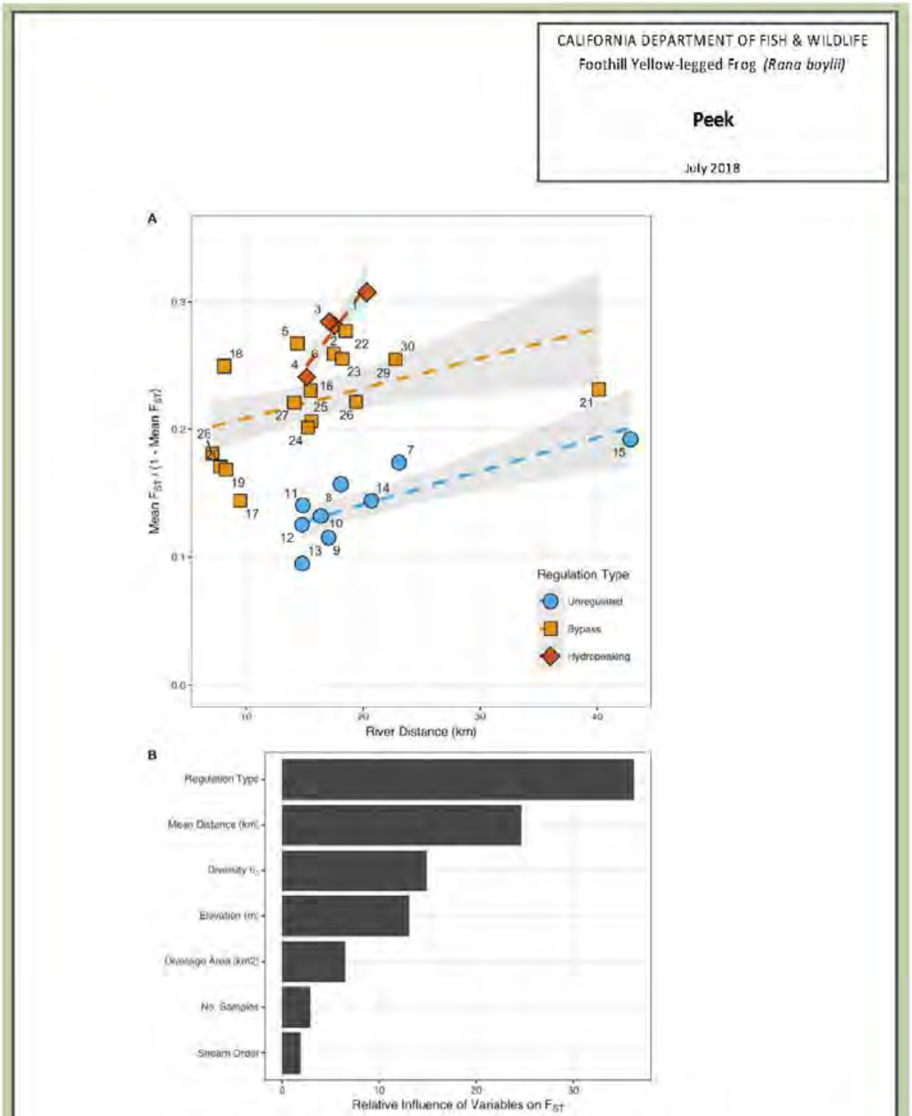


Figure 3. Relationship between river regulation and genetic differentiation in FYLF. A) Mean pairwise F_{ST} vs. mean river distance for each location; B) Relative influence of variables on F_{ST} from boosted regression tree models.

Figure 4. River regulation's relative influence on genetic differentiation from Peek (2018)

can generally be categorized as breeding and rearing habitat, nonbreeding active season habitat, and overwintering habitat (Van Wagner 1996, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011, Hayes et al. 2016, Catenazzi and Kupferberg 2017). Yarnell (2005) located higher densities of Foothill Yellow-legged Frogs in areas with greater habitat heterogeneity and suggested that they were selecting for sites that possessed the diversity of habitats necessary to support each life stage within a relatively short distance.

Breeding and Rearing Habitat

Suitable breeding habitat must be connected to suitable rearing habitat for metamorphosis to be successful. When this connectivity exists, as flows decline through the season, tadpoles can follow the receding shoreline into areas of high productivity and lower predation risk as opposed to becoming trapped in isolated pools with a high risk of overheating, desiccation, and predation (Kupferberg et al. 2009c).

Several studies on Foothill Yellow-legged Frog breeding habitat, carried out across the species' range in California, reported similar findings. Foothill Yellow-legged Frogs select oviposition (egg-laying) sites within a narrow range of depths, velocities, and substrates and exhibit fidelity to breeding sites that consistently possess suitable microhabitat characteristics over time (Kupferberg 1996a, Bondi et al. 2013, Lind et al. 2016). At a coarse-spatial scale, breeding sites in rivers and large streams are often located near the confluence of tributary streams in sunny, wide, shallow reaches (Kupferberg 1996a, Yarnell 2005, GANDA 2008, Peek 2010~~1~~). These areas are highly productive compared to cooler, deeper, closed-canopy sites (Catenazzi and Kupferberg 2013). At a fine-spatial scale, females prefer to lay eggs in low velocity areas dominated by cobble- and boulder-sized substrates, often associated with sparsely-vegetated point bars (Kupferberg 1996a, Lind et al. 1996, Van Wagner 1996, Bondi et al. 2013, Lind et al. 2016). They tend to select areas with less variable, more stable flows, and in areas with higher flows at the time of oviposition, they place their eggs on the downstream side of large cobblestones and boulders, which protects them from being washed away (Kupferberg 1996a, Wheeler et al. 2006).

Appropriate rearing temperatures are vital for successful metamorphosis. Tadpoles grow faster and larger in warmer water to a point (Zweifel 1955; Catenazzi and Kupferberg 2017, 2018). Zweifel (1955) conducted experiments on embryonic thermal tolerance and determined that the critical low was approximate 6°C (43°F), and the critical high was around 26°C (79°F). Welsh and Hodgson (2011) determined that best the single variable for predicting Foothill Yellow-legged Frog presence was temperature since none were observed below 13°C (55°F), but numbers increased significantly with increasing temperature. Catenazzi and Kupferberg (2013) measured tadpole thermal preference at 16.5-22.2°C (61.7-72.0°F), and the distribution of Foothill Yellow-legged Frog populations across a watershed was consistent within this temperature range. At temperatures below 16°C (61°F), tadpoles were absent under closed canopy and scarce even with an open canopy (Ibid.). Catenazzi and Kupferberg (2017) found regional differences in apparently suitable breeding temperatures. Inland populations from primarily snowmelt-fed systems with relatively cold water were relegated to reaches that are warmer on average during the warmest 30 days of the year than coastal populations in the chiefly rainfall-fed, and thus warmer, systems (17.6-24.2°C [63.7-75.6°F] vs. 15.7-22.0°C [60.3-71.6°F], respectively).

However, experiments on tadpole thermal preference demonstrated that individuals from different source populations selected similar rearing temperatures, which presumably optimized development (Ibid.). In regulated systems, where water released from dams is often colder than normal, suitable rearing temperatures downstream may be limited (Wheeler et al. 2014, Catenazzi and Kupferberg 2017).

Appropriate flow velocities are also critical for survival to metamorphosis. The velocity at which Foothill Yellow-legged Frog egg masses shear away from the substrate they are adhered to varies according to factors such as depth and degree to which the eggs are sheltered (Spring Rivers Ecological Sciences 2003). This critical velocity is expected to decrease as the egg mass ages due to the~~ir~~ reduced structural integrity of the protective jelly envelopes (Hayes et al. 2016). Short-duration increases in flow velocity may be tolerated if the egg masses are somewhat sheltered, but sustained high velocities increase the likelihood of detachment (Kupferberg 1996a, Spring Rivers Ecological Sciences 2003). Hatchlings and tadpoles about to undergo metamorphosis are relatively poor swimmers and require especially slow, stable flows during these stages of development (Kupferberg et al. 2011b). Tadpoles respond to increasing flows by swimming against the current to maintain position for a short period of time and eventually swimming to the bottom and seeking refuge in the rocky substrate's interstitial spaces (Ibid.). When tadpoles are exposed to repeated increases in velocities, their growth and development are delayed (Ibid.). Under experimental conditions, the critical velocity at which tadpoles were swept downstream ranged between 20 and 40 cm/s (0.66-1.31 ft/s); however, as they reach metamorphosis it decreases to as low as 10 cm/s (0.33 ft/s) (Ibid.).

Nonbreeding Active Season Habitat

Post-metamorphic Foothill Yellow-legged Frogs utilize a more diverse range of habitats and are much more dispersed during the nonbreeding active season than the breeding season. Microhabitat preferences appear to vary by location and season, but some patterns are common across the species' range. Foothill Yellow-legged Frogs tend to remain close to the water's edge (average < 3 m [10 ft]); select sunny areas with limited canopy cover; and are often associated with riffles and pools (Zweifel 1955, Hayes and Jennings 1988, Van Wagner 1996, Welsh et al. 2005, Haggarty 2006, Bourque 2008, Gonsolin 2010, Welsh and Hodgson 2011). Adequate water, food resources, cover from predators, ability to thermoregulate (e.g., presence of basking sites and cool refugia), and absence of non-native predators are important components of nonbreeding active season habitat (Hayes and Jennings 1988, Van Wagner 1996, Catenazzi and Kupferberg 2013).

Overwintering Habitat

Overwintering habitat varies depending on local conditions, but as with the rest of the year, Foothill Yellow-legged Frogs are most often found in or near water where they can forage and take cover from predators and high discharge events (Storer 1925, Zweifel 1955). In larger streams and rivers, Foothill Yellow-legged Frogs are often found along tributaries during the winter where the risk of being displaced by heavy flows is reduced (Kupferberg 1996a, Gonsolin 2010). Bourque (2008) found 36.4% of adult females used intermittent and ephemeral tributaries during the overwintering season. Van

Wagner (1996) located most overwintering frogs using pools with cover such as boulders, root wads, and woody debris. During high flow events, they moved to the stream's edge and took cover under vegetation like sedges (*Carex* sp.) or leaf litter (Ibid.). Rombough (2006) found most Foothill Yellow-legged Frogs under woody debris along the high-water line and often using seeps along the stream-edge, which provided them with moisture, a thermally stable environment, and prey.

Exceptions to the pattern of remaining near the stream's edge during winter have been reported. Cook et al. (2012) observed dozens of juvenile Foothill Yellow-legged Frogs traveling over land, as opposed to using riparian corridors. They were found using upland habitats with an average distance of 71.3 m (234 ft) from water (range: 16-331 m [52-1,086 ft]) (Ibid.). In another example, a single subadult that was found adjacent to a large wetland complex 830 m (2,723 ft) straight-line distance from the wetted edge of the Van Duzen River, although it is possible the wetland was connected to the river via a spillway or drainage that may have served as the movement corridor (CDFW 2018a, R. Bourque pers. comm. 2019).

Seasonal Activity and Movements

Because Foothill Yellow-legged Frogs occupy areas with relatively mild winter temperatures, they can be active year-round, although at low temperatures (< 7°C [44 °F], they become lethargic (Storer 1925, Zweifel 1955, Van Wagner 1996, Bourque 2008). They are active both day and night, and during the day adults are often observed basking on warm objects such as sun-heated rocks, although this is also when their detectability is highest (Fellers 2005, Wheeler et al. 2005). By contrast, Gonsolin (2010) tracked radio-telemetered Foothill Yellow-legged Frogs under substrate a third of the time and underwater a quarter of the time, although nearly all his detections of frogs without transmitters were basking.

Adult Foothill Yellow-legged Frogs migrate from their overwintering sites to breeding habitat in the spring, often from a tributary to its confluence with a larger stream or river. In areas where tributaries dry down, juveniles also make this downstream movement (Haggarty 2006). When the tributary itself is perennial and provides suitable breeding habitat, the frogs may not undertake these long-distance movements (Gonsolin 2010). Cues for adults to initiate this migration to breeding sites are somewhat enigmatic and vary by location, elevation, and amount of precipitation (S. Kupferberg and A. Lind pers. comm. 2017). They can also include day length, water temperature, and sex (GANDA 2008, Gonsolin 2010, Yarnell et al. 2010, Wheeler et al. 2018). Males initiate movements to breeding sites where they congregate in leks (areas of aggregation for courtship displays), and females arrive later and over a longer period (Wheeler and Welsh 2008, Gonsolin 2010). Most males utilize breeding sites associated with their overwintering tributaries, but some move substantial distances to other sites and may use more than one breeding site in the same season (Wheeler and Welsh 2006, GANDA 2008).

While the predictable hydrograph in California consists of wet winters with high flows and dry summers with low flows, the timing and quantity of seasonal discharge can vary significantly from year to year. The timing of oviposition can influence offspring growth and survival. Early breeders risk scouring of egg masses from their substrate by late spring storms in wet years or desiccation if waters recede rapidly, but when they successfully hatch, tadpoles benefit from a longer growing season, which can enable them to metamorphose at a larger size and increase their likelihood of survival (Railsback et al. 2016).

Later breeders are less likely to have their eggs scoured away or desiccated because flows are generally more stable, but they have fewer mate choices, and their tadpoles have a shorter growing period before metamorphosis, reducing their chance of survival (Ibid.). Some evidence indicates larger females, who coincidentally lay larger clutches, breed earlier (Kupferberg et al. 2009c, Gonsolin 2010). Consequently, early season scouring or stranding of egg masses or tadpoles can disproportionately impact the population's reproductive output because later breeders produce fewer and smaller eggs per clutch (Kupferberg et al. 2009c, Gonsolin 2010).

Timing of oviposition is often a function of water temperature and flow, but it consistently occurs on the descending limb of the hydrograph which corresponds to high ~~high winter discharge~~spring discharge gradually receding toward low summer baseflow (Kupferberg 1996a, GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010, Yarnell et al. 2010). Under natural conditions, the timing coincides with intermittent tributaries drying down and increases in algal blooms that provide forage for tadpoles (Haggarty 2006, Power et al. 2008). At lower elevations, breeding can start in late March or early April, and at mid-elevations, breeding typically occurs in mid-May to mid-June (Gonsolin 2010, S. Kupferberg and A. Lind pers. comm. 2017). The time of year a population initiates breeding can vary by a month among water years, occurring later at deeper sites when colder water becomes warmer (Wheeler et al. 2018). In wetter years, delayed breeding into early July can occur in some colder snowmelt systems (S. Kupferberg and A. Lind pers. comm. 2017, GANDA 2018).

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A population's period of oviposition can also vary from two weeks to three months, meaning they could be considered explosive breeders at some sites and prolonged breeders at others (Storer 1925, Zweifel 1955, Van Wagner 1996, Ashton et al. 1997, Wheeler and Welsh 2008). Water temperature typically warms to over 10°C (50°F) before breeding commences (GANDA 2008, Gonsolin 2010, Wheeler et al. 2018). Wheeler and Welsh (2008) observed Foothill Yellow-legged Frogs breeding when flows were below 0.6 m/s (2 ft/s), pausing during increased flows until they receded, and GANDA (2008) reported breeding initiated when flow decreased to less than 55% above baseflow.

Male Foothill Yellow-legged Frogs spend more time at breeding sites during the season than females, many of whom leave immediately after laying their eggs (GANDA 2008, Wheeler and Welsh 2008, Gonsolin 2010). Daily movements are usually short (< 0.3 m [1 ft]), but some individuals travel substantial distances: median 70.7 m/day (232 ft/day) in spring and 37.1 m/day (104 ft/day) in fall/winter, nearly always using streams as movement corridors (Van Wagner 1996, Bourque 2008, Gonsolin 2010). The maximum reported movement rate is 1,386 m/d (0.86 mi/day), and the longest seasonal (post-breeding) daily distance reported is 7.04 km (4.37 mi) by a female that traveled up a dry tributary and over a ridge before returning to and moving up the mainstem creek (Bourque 2008). Movements during the non-breeding season are typically in response to drying channels or during rain events (Bourque 2008, Gonsolin 2010, Cook et al. 2012).

Hatchling Foothill Yellow-legged Frog tadpoles~~s~~ tend to remain with what is left of the egg mass for several days before dispersing into the interstitial spaces in the substrate (Ashton et al. 1997). They often move downstream in areas of moderate flow and will follow the location of warm water in the channel throughout the day (Brattstrom 1962, Ashton et al. 1997, Kupferberg et al. 2011a). Tadpoles usually metamorphose in late August or early September (S. Kupferberg and A. Lind pers. comm. 2017). Twitty et al. (1967) reported that newly metamorphosed Foothill Yellow-legged Frogs mostly migrated upstream, which may be an evolutionary mechanism to return to their natal site after being washed downstream (Ashton et al. 1997).

Home Range and Territoriality

Foothill Yellow-legged Frogs exhibit a lek-type mating system in which males aggregate at the breeding site and establish calling territories (Wheeler and Welsh 2008, Bondi et al. 2013). The species has a relatively large calling repertoire for western North American ranids with seven unique vocalizations recorded (Silver 2017). Some of these can be reasonably attributed to territory defense and mate attraction communications (MacTeague and Northen 1993, Silver 2017). Physical aggression among males during the breeding season has been reported (Rombough and Hayes 2007, Wheeler and Welsh 2008). In addition, Wheeler and Welsh (2008) observed a non-random mating pattern in which males engaged in amplexus with females were larger than males never seen in amplexus, suggesting either physical competition or female preference for larger individuals. Very little information has been published on Foothill Yellow-legged Frog home range size. Wheeler and Welsh (2008) studied males during a 17-day period during breeding season and classified some of them "site faithful" based on their movements and calculated their home ranges. Two-thirds of males tracked were site faithful, and their mean home range size was 0.58 m^2 (SE = 0.10 m^2; 6.24 ft^2 [SE = 1.08 ft^2]) (Ibid.). In contrast, perhaps because the study took place over a longer time period, Bourque (2008) reported approximately half of the males he tracked during the spring were mobile, and the other half were sedentary. The median distances traveled along the creek (a proxy for home range size since they rarely leave the riparian corridor) for mobile and sedentary males were 149 m (489 ft) and 5.5 m (18 ft), respectively.

Diet and Predators

Foothill Yellow-legged Frog diet varies by life stage and likely body size. Tadpoles graze on periphyton (algae growing on submerged surfaces) scraped from rocks and vegetation and grow faster, and to a larger size, when it contains a greater proportion of epiphytic diatoms with nitrogen-fixing endosymbionts (*Epithemia* spp.), which are high in protein and fat (Kupferberg 1997b, Fellers 2005, Hayes et al. 2016, Catennazi and Kupferberg 2017). Tadpoles may also forage on necrotic tissue from dead bivalves and other tadpoles, or more likely the algae growing on them (Ashton et al. 1997, Hayes et al. 2016). Post-metamorphic Foothill Yellow-legged Frogs primarily feed on a wide variety of terrestrial arthropods but also some aquatic invertebrates (Fitch 1936, Van Wagner 1996, Haggarty 2006). Most of their diet consists of insects and arachnids (Van Wagner 1996, Haggarty 2006, Hothem et al. 2009). Haggarty (2006) did not identify any preferred taxonomic groups, but she noted larger Foothill Yellow-legged Frogs consumed a greater proportion of large prey items compared to smaller individuals, suggesting the species may be gape-limited generalist predators. Hothem et al. (2009) found mammal hair and bones in a Foothill Yellow-legged Frog. Adult Foothill Yellow-legged Frogs, like many other ranids, also cannibalize conspecifics (Wiseman and Bettaso 2007). In the fall when young-of-year are abundant, they may provide an important source of nutrition for adults prior to overwintering (Ibid.).

Foothill Yellow-legged Frogs are preyed upon by several native and introduced species, including each other as described above. Some predators target specific life stages, while others may consume multiple stages. Several species of gartersnakes (genus *Thamnophis*) are the primary and most widespread group of native predators on Foothill Yellow-legged Frogs tadpoles through adults is (Fitch 1941, Fox 1952, Zweifel 1955, Lind and Welsh 1994, Ashton et al. 1997, Wiseman and Bettaso 2007, Gonsolin 2010). Table 1 lists other known and suspected predators of Foothill Yellow-legged Frogs.

Table 1. Confirmed and potential Foothill Yellow-legged Frog predators in California in addition to gartersnakes (*Thamnophis* spp.)

Common Name	Scientific Name	Classification	Native	Prey Life Stage(s)	Sources
Caddisfly (larva)	*Dicosmoecus gilvipes*	Insect	Yes	Embryos (eggs)	Rombough and Hayes 2005
Dragonfly (nymph)	*Aeshna walker*	Insect	Yes	Larvae	Catenazzi and Kupferberg 2018
Waterscorpion	*Ranatra brevicollis*	Insect	Yes	Larvae	Catenaazi and Kupferberg 2018
Signal Crayfish	*Pacifastacus leniusculus*	Crustacean	No	Embryos (eggs) and Larvae	Rombough and Hayes 2005; Wiseman et al. 2005
Speckled Dace	*Rhinichthys osculus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Reticulate Sculpin	*Cottus perplexus*	Fish	Yes	Larvae	Rombough and Hayes 2005
Sacramento Pike-mMinnow	*Ptychocheilus grandis*	Fish	Yes*	Embryos (eggs) and Adults	Ashton and Nakamoto 2007
Sunfishes	Family Centrachidae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Catfishes	Family Ictaluridae	Fish	No	Larvae	Moyle (1973); Hayes and Jennings 1986
Rough-skinned Newt	*Taricha granulosa*	Amphibian	Yes	Embryos (eggs)	Evenden 1948
California Giant Salamander	*Dicamptodon ensatus*	Amphibian	Yes	Larvae	Fidenci 2006
American Bullfrog	*Rana catesbeiana*	Amphibian	No	Larvae to Adults	Crayon 1998; Hothem et al. 2009
California Red-legged Frog	*Rana draytonii*	Amphibian	Yes	Larvae to Adults	Gonsolin 2010
American Robin	*Turdus migratorius*	Bird	Yes	Larvae	Gonsolin 2010
Common Merganser	*Mergus merganser*	Bird	Yes	Larvae	Gonsolin 2010
American Dipper	*Cinclus mexicanus*	Bird	Yes	Larvae	Ashton et al. 1997
Mallard	*Anas platyrhynchos*	Bird	Yes	Adults	Rombough et al. 2005
Raccoon	*Procyon lotor*	Mammal	Yes	Larvae to Adults	Zweifel 1955; Ashton et al. 1997
River Otter	*Lontra canadensis*	Mammal	Yes	Adults	T. Rose pers. comm. 2014

* Introduced to the Eel River, location of documented predation; Foothill Yellow-legged Frogs are extirpated from most areas of historical range overlap

Commented [RAP8]: Do you have a copy of Susan Corum's thesis from Humboldt State? It's from 2003 and is about the effects of sac pikeminnow on FYLF in coastal streams…should probably add as citation here too.

Corum, S. D. (2003). *Effects of Sacramento Pikeminnow on Foothill Yellow-Legged Frogs in Coastal Streams* (August). Humboldt State University.

STATUS AND TRENDS IN CALIFORNIA

Administrative Status

Sensitive Species

The Foothill Yellow-legged Frog is listed as a Sensitive Species by the U.S. Bureau of Land Management (BLM) and U.S. Forest Service (Forest Service). These agencies define Sensitive Species as those species that require special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA.

California Species of Special Concern

The Department's Species of Special Concern (SSC) designation is similar to the federal Sensitive Species designation. It is administrative, rather than regulatory in nature, and intended to focus attention on animals at conservation risk. The designation is used to stimulate needed research on poorly known species and to target the conservation and recovery of these animals before they meet the CESA criteria for listing as threatened or endangered (Thomson et al. 2016). The Foothill Yellow-legged Frog is listed as a Priority 1 (highest risk) SSC (Ibid.).

Trends in Distribution and Abundance

Range-wide in California

Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551). Systematic, focused, range-wide assessments of Foothill Yellow-legged Frog distribution and abundance are rare, both historically and contemporarily. A detailed account of what has been documented within the National Parks and National Forests in California can be found in Appendix 3 of the *Foothill Yellow-legged Frogs Conservation Assessment in California* (Hayes et al. 2016).

Most Foothill Yellow-legged Frog records are incidental observations made during stream surveys for ESA-listed salmonids and simply document presence at a particular date and location, although some include counts or estimates of abundance by life stage. This makes assessing trends in distribution and abundance difficult despite a relatively large number of observations compared to many other species tracked by the California Natural Diversity Database (CNDDB). The CNDDB contained 2,366 Foothill Yellow-legged Frog occurrences in its March 2019 edition, 500 of which are documented from the past 5 years.

A few wide-ranging survey efforts that included Foothill Yellow-legged Frogs exist. Reports from early naturalists suggest Foothill Yellow-legged Frogs were relatively common in the Coast Ranges as far south as central Monterey County, in eastern Tehama County, and in the foothills in and near Yosemite National Park (Grinnell and Storer 1924, Storer 1925, Grinnell et al. 1930, Martin 1940). In addition to

these areas, relatively large numbers of Foothill Yellow-legged Frogs (17-35 individuals) were collected at sites in the central and southern Sierra Nevada and the San Gabriel Mountains between 1911 and 1950 (Hayes et al. 2016). Widespread disappearances of Foothill Yellow-legged Frog populations were documented as early as the 1970s and 80s in southern California, the southern Coast Range, and the central and southern Sierra Nevada foothills (Moyle 1973, Sweet 1983).

Twenty-five years ago, the Department published the first edition of *Amphibians and Reptile Species of Special Concern in California* (Jennings and Hayes 1994). The authors revisited hundreds of localities that had historically been occupied by Foothill Yellow-legged Frogs between 1988 and 1991 and consulted local experts to determine presumed extant or extirpated status. Based on these survey results and stressors observed on the landscape, they considered Foothill Yellow-legged Frogs endangered in central and southern California south of the Salinas River in Monterey County. They considered the species threatened in the west slope drainages of the Cascade Mountains and Sierra Nevada east of the Central Valley, and they considered the remainder of the range to be of special concern (Ibid.).

Fellers (2005) and his field crews conducted surveys for Foothill Yellow-legged Frogs throughout California. They visited 804 sites across 40 counties with suitable habitat within the species' historical range. They detected at least one individual at 213 sites (26.5% of those surveyed) over 28 counties. They located Foothill Yellow-legged Frogs in approximately 40% of streams in the North Coast, 30% in the Cascade Mountains and south of San Francisco in the Coast Range, and 12% in the Sierra Nevada. Fellers estimated population abundance was 20 or more adults at only 14% of the sites where the species was found and noted the largest and most robust populations occurred along the North Coast. In addition, to determine status of Foothill Yellow-legged Frogs across the species' range and potential causes for declines, Lind (2005) used previously published status accounts, species expert and local biologist professional opinions, and field visits to historically occupied sites between 2000-2002. She determined that Foothill Yellow-legged Frogs had disappeared from 201 of 394 of the sites, representing just over 50%. The coarse-scale trend in California is one of greater population declines and extirpations of amphibians? Or just FYLF? in lower elevations and latitudes (Davidson et al. 2002).

Few site-specific population trend data are available from which to evaluate status. However, long-term monitoring efforts often use egg mass counts as a proxy to estimate adult breeding females. The results of these studies often reveal extreme interannual variability in number of egg masses laid (Ashton et al. 2010, S. Kupferberg and M. Power pers. comm. 2015, Peek and Kupferberg 2016). In a meta-analysis of egg mass count data collected across the species' range in California over the past 25 years, Peek and Kupferberg (2016) reported declines in two unregulated rivers and an increase in another. Their models did not detect any significant trends in abundance across different locations or regulation type (dammed or undammed); however, high interannual variability can render trend detection difficult. Interannual variability was substantially greater in regulated rivers vs. unregulated; the median coefficient of variation was 66.9% and 41.6%, respectively (Ibid.). The greater variability in regulated rivers decreases the probability of detecting significant declines, and coupled with low abundance, it can lead to populations dropping below a density necessary for persistence without detection, resulting in extirpation.

Regional differences in Foothill Yellow-legged Frog persistence across its range have been recognized for nearly 50 years (i.e., more extirpations documented in the south). Because of these differences and the recent availability of new landscape genomic data, more detailed descriptions of trends in Foothill Yellow-legged Frog population distribution and abundance in California are evaluated by clade below. Figure 5 depicts Foothill Yellow-legged Frog localities across all clades in California by the most recent confirmed sighting in the datasets available to the Department within a Public Lands Survey System (PLSS) section. "Transition Zones" are those areas where the exact clade boundaries are unknown due to a lack of samples. In addition, while not depicted as an area of uncertainty, no genetic samples have been tested south of the extant population in northern San Luis Obispo County, in the Sutter Buttes in Sutter County, or northeastern Plumas County. It is possible there were historically more clades than currently understood.

Caution should be exercised in comparing the following observation data across the species' range and across time since survey effort and reporting are not standardized. These data can be useful for making some general inferences about distribution, abundance, and trends. For instance, assuming the observation correctly identifies the species, the date on the record is the last time the species was confirmed to have occurred at that location. However, this only works in the affirmative. For example, at a site where the last time the species was seen was 75 years ago, the species may still persist there if no one has surveyed it since the original observation. CNDDB staff use information on land use conversion, follow-up visits, and biological reports to categorize an occurrence location as "extirpated" or "possibly extirpated".

Northwest/North Coast Clade

This clade extends from north of San Francisco Bay through the Coast Range and Klamath Mountains to the northern limit of the Foothill Yellow-legged Frog's range and east through the Cascade Range. It includes Del Norte, Siskiyou, Humboldt, Trinity, Shasta, Tehama, Mendocino, Glenn, Colusa, Lake, Sonoma, Napa, Yolo, Solano, and Marin counties. This clade covers the largest geographic area and contains the greatest amount of genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). In addition, it is the only clade with an increasing trend in genetic diversity (Peek 2018).

Early records note the comparatively high abundance of Foothill Yellow-legged Frogs in this area. Storer (1925) described Foothill Yellow-legged Frogs as very common in many of Coast Range streams north of San Francisco Bay, and Cope (1879,1883 as cited in Hayes et al. 2016) noted they were "rather abundant in the mountainous regions of northern California." In addition, relatively large collections occurred over short periods of time in this region in the late 1800s and the first half of the 20th century (Hayes et al. 2016). Nineteen were taken over two weeks in 1893 along Orrs Creek, a tributary to the Russian River, and 40 from near Willits (both in Mendocino County) in 1911; 112 were collected over three days at Skaggs Spring (Sonoma County) in 1911; 57 were taken in one day along Lagunitas Creek (Marin County) in 1928; and 50 were collected in one day near Denny (Trinity County) in 1955 (Ibid.).

A few long-term Foothill Yellow-legged Frog egg mass monitoring efforts undertaken within this clade's boundaries found densities vary significantly, often based on river regulation type, and documented

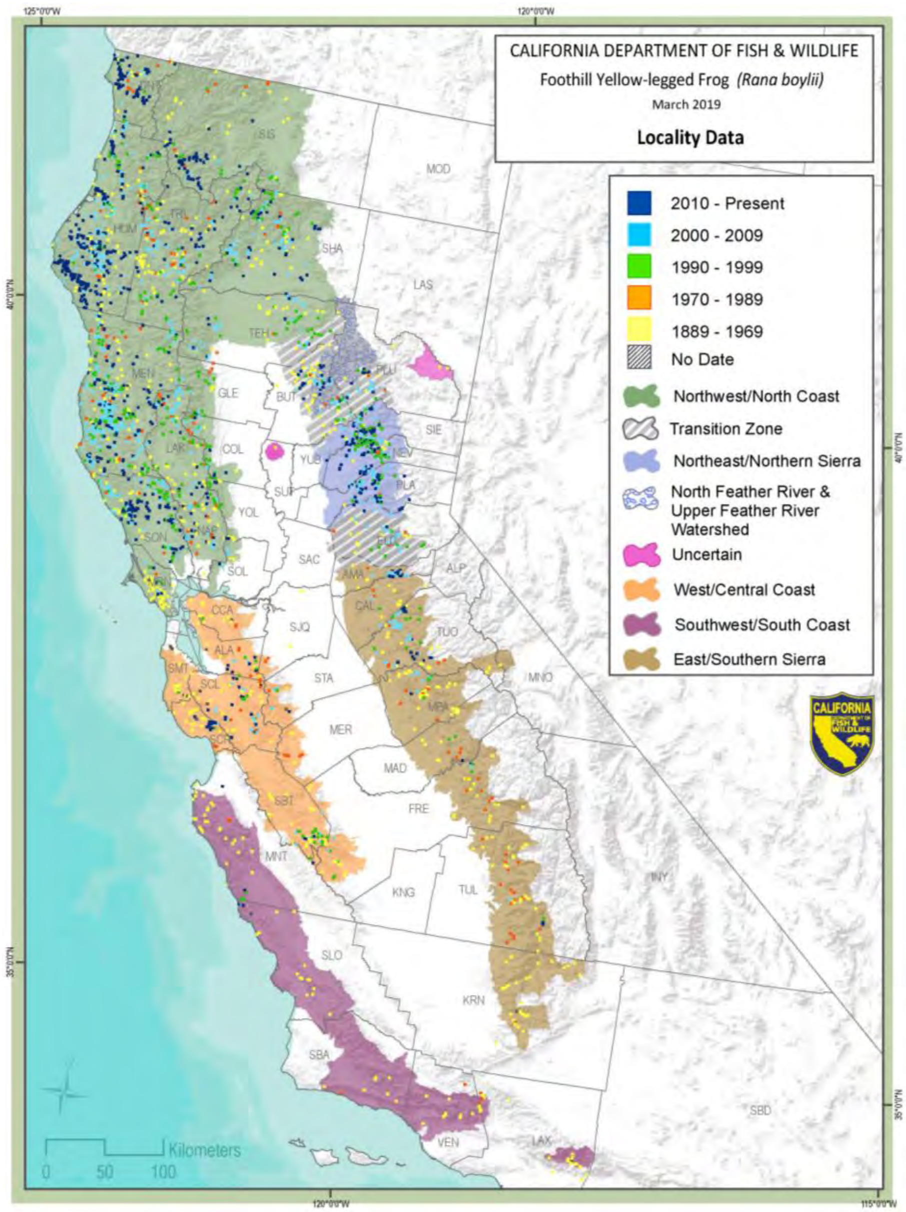

Figure 5. Foothill Yellow-legged Frog occurrence data from 1889-2019 overlaying the six clades by most recent sighting in a Public Lands Survey System section (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

several robust populations. The Green Diamond Resources Company has been monitoring a stretch of the Mad River near Blue Lake (Humboldt County) since 2008 (GDRC 2018). The greatest published density of Foothill Yellow-legged Frog egg masses was documented here in 2009 at 323.6 egg masses/km (520.7/mi) (Bourque and Bettaso 2011). However, in 2017, surveyors counted 625.1 egg masses/km (1,006/mi) along the same reach (GDRC 2018). At its lowest during this period, egg mass density was calculated at 71.54/km (115.1/mi) in 2010, although this count occurred after a flooding even that likely scoured over half of the egg masses laid that season (GDRC 2018, R. Bourque pers. comm. 2019). During a single day survey in 2017 along approximately 2 km (1.3 mi) of Redwood Creek in Redwood National Park (Humboldt County), 2,009 young and 126 adult Foothill Yellow-legged Frogs were found (D. Anderson pers. comm. 2017). Some reaches of the South Fork Eel River (Mendocino County) also support high densities of Foothill Yellow-legged Frogs. Kupferberg (pers. comm. 2018) recorded 206.9 and 106.2 egg masses/km (333 and 171/mi) along two stretches in 2016, and 201.7 and 117.5 egg masses/km (324 and 189/mi) in 2017. However, other reaches yielded counts as low as 6.1 and 8.4 egg masses/km (9.8 and 13.5/mi) (Ibid.). In the Angelo Reserve (an unregulated reach), the 24-year mean density was 109 egg masses/km (175.4/mi) (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015). In contrast, a 10-year mean density of egg masses below Lewiston Dam on the Trinity River (Trinity County) was 0.89/km (1.43/mi) (Ibid.).

Figure 6 depicts PLSS sections with positive sightings of Foothill Yellow-legged Frogs from the CNDDB, Biological Information Observation System datasets, and personal communications that are color coded by the most recent date of detection. Within this clade, Foothill Yellow-legged Frogs were observed in at least 343 areas in the past 5 years (CNDDB 2019). The species remains widespread within many watersheds, although most observations only verify presence, or fewer than ten individuals or egg masses are recorded (Ibid.). Documented extirpations are comparatively rare, but also likely undetected or under-reported, and nearly all occurred just north of the high-populated San Francisco Bay area (Figure 7; Ibid.).

West/Central Coast

This clade extends south from the San Francisco Bay through the Diablo Range and down the peninsula through the Santa Cruz and Gabilan Mountains in the Coast Range east of the Salinas Valley. It includes most of Contra Costa, Alameda, San Mateo, Santa Cruz, Santa Clara, and San Benito counties; western San Joaquin, Stanislaus, Merced, and Fresno counties; and a small portion of eastern Monterey County. Records of Foothill Yellow-legged Frogs occurring south of San Francisco Bay did not exist until specimens were collected in 1918 around what is now Pinnacles National Park in San Benito County, and little information exists on historical distribution and abundance within this clade (Storer 1923).

Within this clade, Foothill Yellow-legged Frogs were observed in at least 24 areas in the past five years (Figure 8; CNDDB 2019). Documented and possible extirpations are concentrated around the San Francisco Bay and sites at the southern portion of the clade's range, although these may not have been resurveyed since their original observations in the 1940s through 1960s, except for a site in Pinnacles National Park that was surveyed in 1994 (Figure 9; Ibid.). In addition, although not depicted,

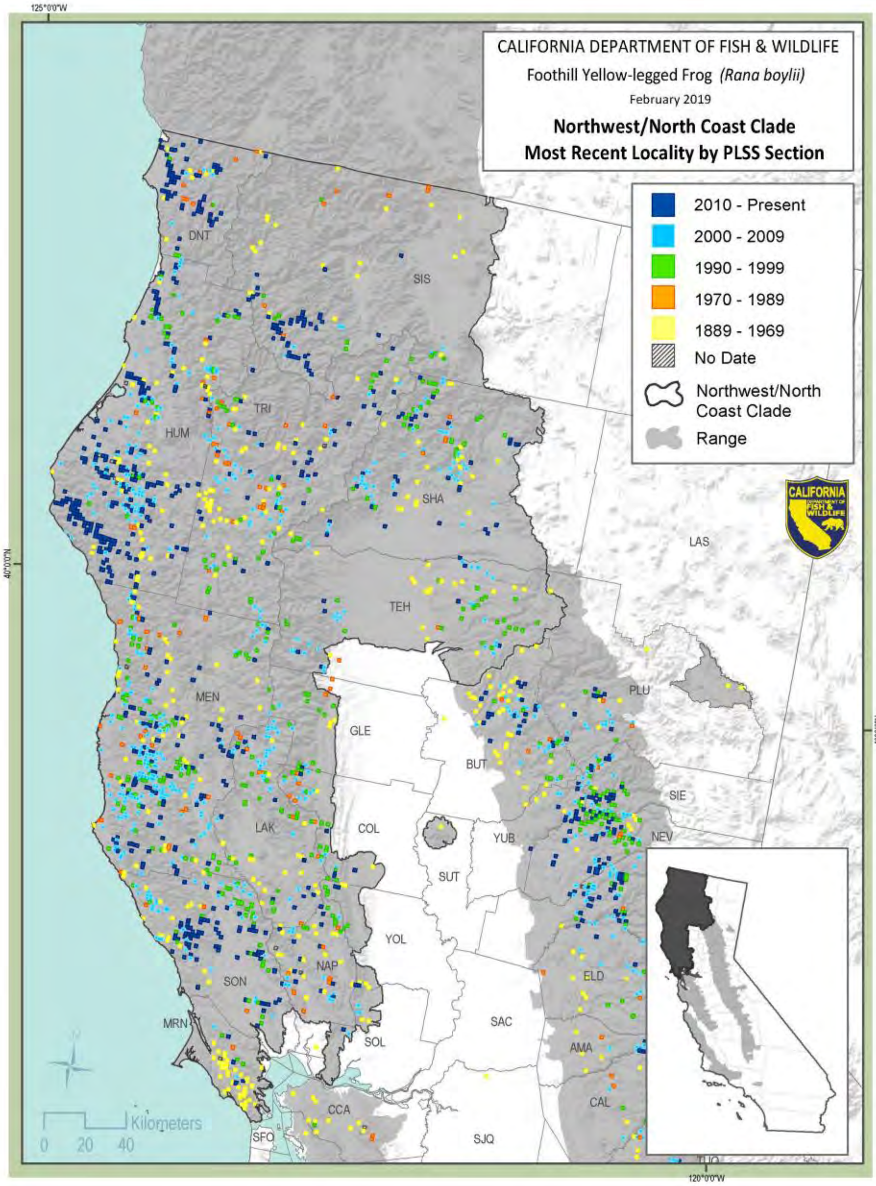

Figure 6. Close-up of Northwest/North Coast Foothill Yellow-legged Frog clade observations from 1889-2019 (ARSSC, BIOS, CDFW, CNDDB, HRC, MRC)

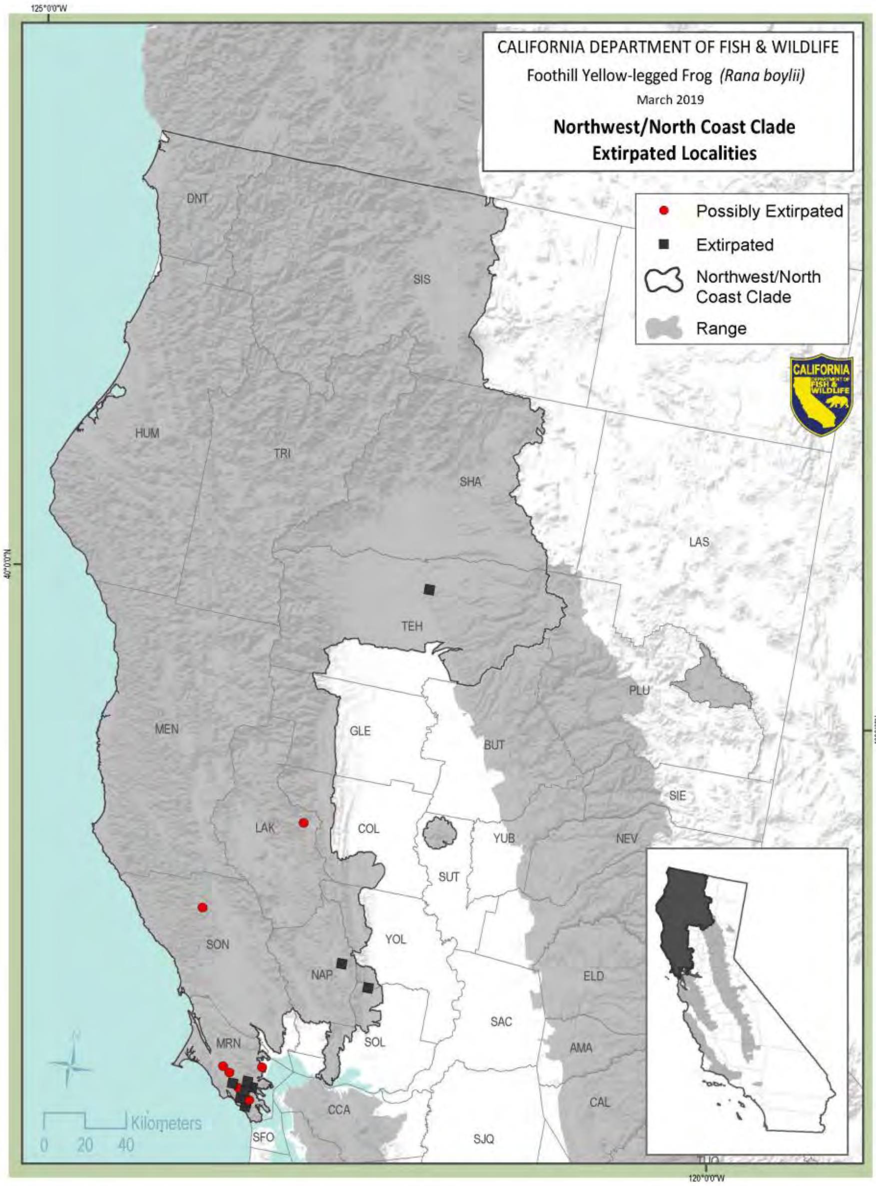

Figure 7. Possibly extirpated and extirpated Northwest/North Coast Foothill Yellow-legged Frog clade sites (CNDDB)

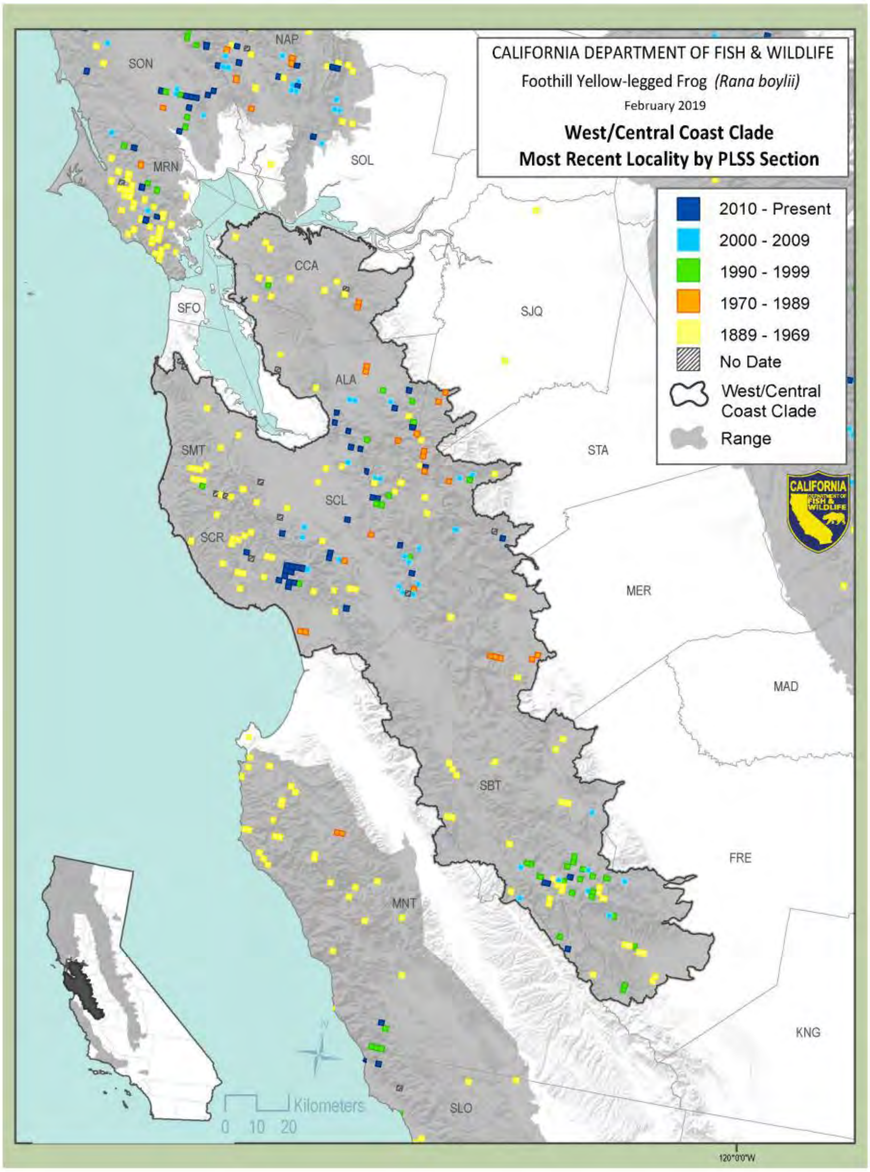

Figure 8. Close-up of West/Central Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

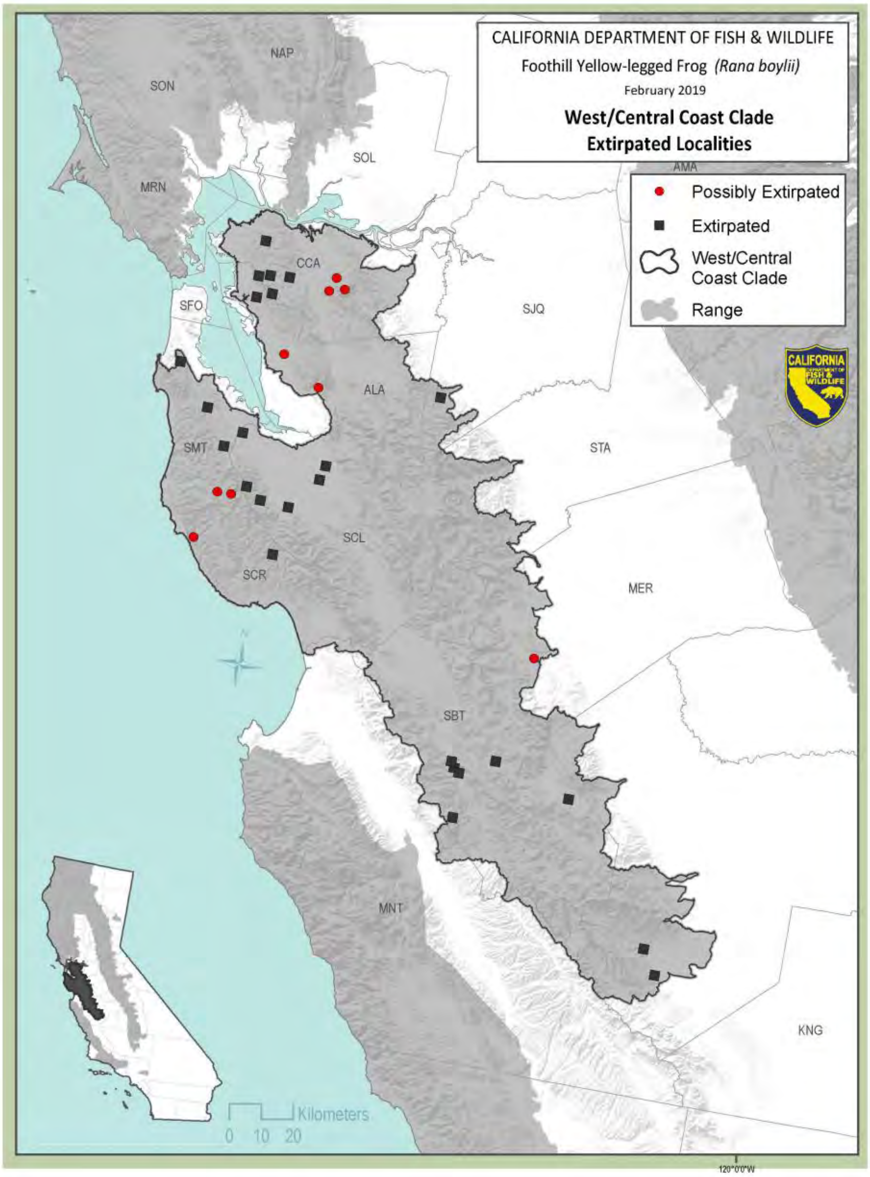

Figure 9. Possibly extirpated and extirpated West/Central Coast Foothill Yellow-legged Frog clade sites (CNDDB)

two populations on Arroyo Mocho and Arroyo Valle south of Livermore (Alameda County) are also likely extirpated (M. Grefsrud pers. comm. 2019).

The San Francisco Bay Area is heavily urbanized. Foothill Yellow-legged Frogs may be gone from Contra Costa County; eight of the nine CNDDB records from the county are museum specimens collected between 1891 and 1953, and the most recent observation was two adults in a plunge pool in an intermittent tributary to Moraga Creek in 1997. No recent (2010 or later) observations exist from San Mateo County (Ibid.). Historically occupied lower-elevation sites surrounding the San Francisco Bay and inland appear to be extirpated, but there are (or were) some moderately abundant breeding populations remaining at higher elevations in Arroyo Hondo (Alameda County), Alameda Creek (Alameda and Santa Clara counties), Coyote and Upper Llagas creeks (Santa Clara County), and Soquel Creek (Santa Cruz County) with some scattered smaller populations also persisting in these counties (J. Smith pers. comm. 2016, 2017; CNDDB 2019). The Alameda Creek and Coyote Creek populations recently underwent large-scale mortality events, so their numbers are likely substantially lower than what is currently reported in the CNDDB (Adams et al. 2017a, Kupferberg and Catenazzi 2019). In addition, the Arroyo Hondo population will lose approximately 1.6 km (1 mi) of prime breeding habitat (i.e., supported the highest density of egg masses on the creek) as the Calaveras Reservoir is refilled following its dam replacement project in 2019 (M. Grefsrud pers. comm. 2019). Foothill Yellow-legged Frogs may be extirpated from Corral Hollow Creek in San Joaquin County, but a single individual was observed five years ago further up the drainage in Alameda County within an Off-Highway Vehicle park (CNDDB 2019). Few recent sightings of Foothill Yellow-legged Frogs in the east-flowing creeks are documented. They may still be extant in the headwaters of Del Puerto Creek (western Stanislaus County), but the records further downstream indicate bullfrogs (known predators and disease reservoirs) are moving up the system (Ibid.). Several locations in southern San Benito, western Fresno, and eastern Monterey counties have relatively recent (2000 and later) detections (Ibid.). However, while many of these sites supported somewhat large populations in the 1990s, the more recent records report fewer than ten individuals (Ibid.). The exception is a Monterey County site where around 25 to 30 were observed in 2012 (Ibid.).

Southwest/South Coast

Widespread extirpations occurred decades ago, primarily in the 1960s and 1970s, in this area (Adams et al. 2017b). As a result, genetic samples were largely unavailable, and the boundaries are speculative. The clade is presumed to include the Coast Range from Monterey Bay south to the Transverse Range across to the San Gabriel Mountains. This clade includes portions of Monterey, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties. Storer (1923) reported that Foothill Yellow-legged Frogs were collected for the first time in Monterey County in 1919 and that a specimen collected by Cope in 1889 in Santa Barbara and listed as *Rana temporaria pretiosa* may refer to the Foothill Yellow-legged Frog because as previously mentioned, the taxonomy of this species changed several times over the first century after it was named.

Foothill Yellow-legged Frogs had been widespread and fairly abundant in this area until the late 1960s (Figure 10) but were rapidly extirpated throughout the southern Coast Ranges and western Transverse

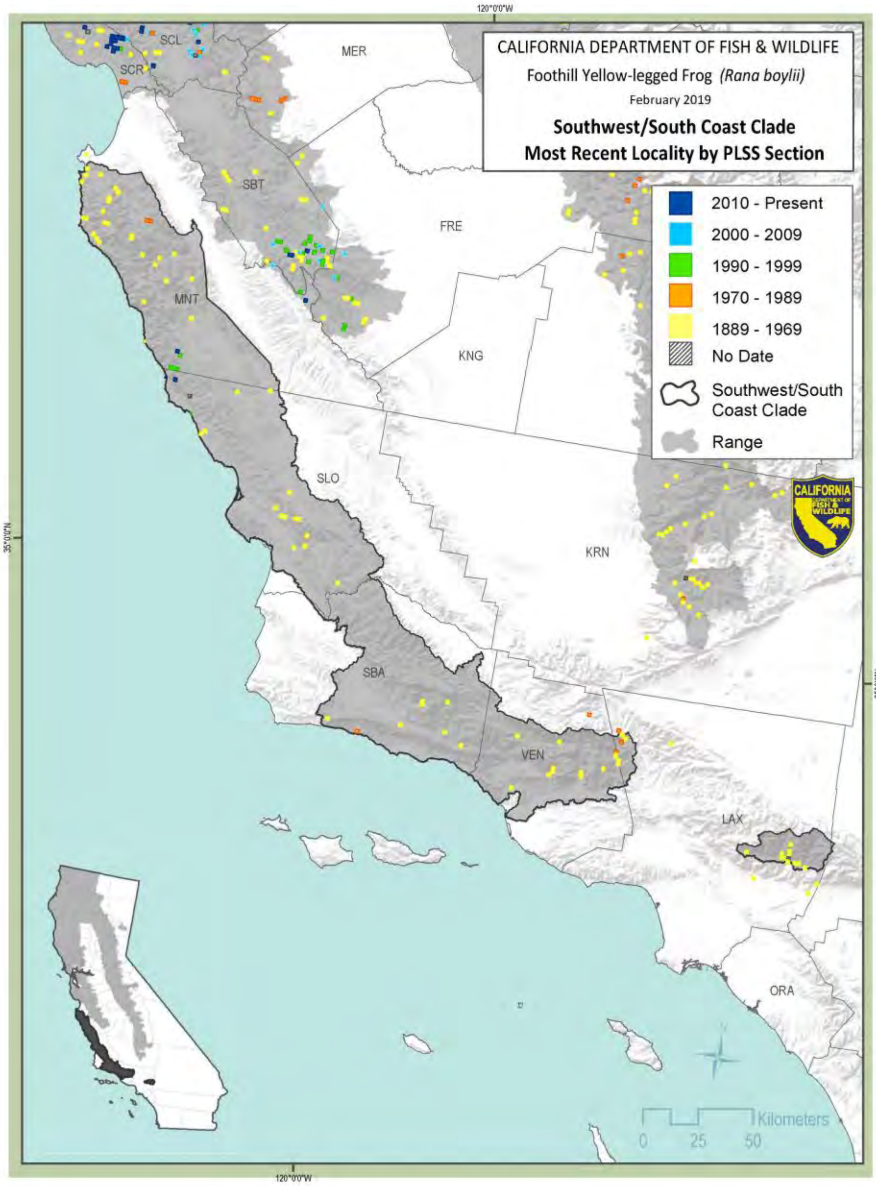

Figure 10. Close-up of Southwest/South Coast clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

Ranges by the mid-1970s (Figure 11; Sweet 1983, Adams et al. 2017b). Only two known extant populations exist from this clade, located near the border of Monterey and San Luis Obispo counties (S. Sweet pers. comm. 2017, McCartney-Melstad et al. 2018, Peek 2018, CNDDB 2019). They appear to be extremely small and rapidly losing genetic diversity, making them at high risk of extirpation (McCartney-Melstad et al. 2018, Peek 2018).

Northeast/Feather River and Northern Sierra

The exact clade boundaries in the Sierra Nevada are unclear and will require additional sampling and testing to define (Figure 12). The Northeast clade presumably encompasses the Feather River and Northern Sierra clades. The Feather River clade is located primarily in Plumas and Butte counties. The Northern Sierra clade roughly extends from the Feather River watershed south to the Middle Fork American River. It includes portions of El Dorado, Placer, Nevada, Sierra, and Plumas counties. It may also include portions of Amador, Butte, and eastern Tehama counties. No genetic samples were available to test in the Sutter Buttes or the disjunct population in northeastern Plumas County to determine which clades they belonged to before they were extirpated (Figure 13; Olson et al. 2016, CNDDB 2019).

In general, there is a paucity of historical Foothill Yellow-legged Frog data for west-slope Sierra Nevada streams, particularly in the lower elevations of the Sacramento Valley, and no quantitative abundance data exist prior to major changes in the landscape (i.e., mining, dams, and diversions) or the introduction of non-native species (Hayes et al. 2016). Foothill Yellow-legged Frogs have been collected frequently from the Plumas National Forest area in small numbers from the turn of the 20th century through the 1970s (Ibid.). Estimates of relative abundance are not clear from the records, but they suggest the species was somewhat widespread in this area.

More recently, Foothill Yellow-legged Frog populations in the Sierra Nevada have been the subject of a substantial number of surveys and focused research associated with recent and ongoing relicensing of hydroelectric power generating dams by the Federal Energy Regulatory Commission (FERC). Consequently, Foothill Yellow-legged Frogs have been observed in at least 30 areas in Plumas and Butte counties (roughly the Feather River clade) over the past five years (CNDDB 2019). As with the rest of the range, most records are observations of only a few individuals; however, many observations occurred over multiple years, and in some cases all life stages were observed over multiple years (Ibid). The populations appear to persist even with the small numbers reported. The only long-term consistent survey effort has been occurring on the North Fork Feather River along the Cresta and Poe reaches (GANDA 2018). The Cresta reach's subpopulation declined significantly in 2006 and never recovered despite modification of the flow regime to reduce egg mass and tadpole scouring and some habitat restoration (Ibid.). A pilot project to augment the Cresta reach's subpopulation through in situ captive rearing was initiated in 2017 (Dillingham et al. 2018). It resulted in the highest number of young-of-year Foothill Yellow-legged Frogs recorded during fall surveys since researchers started keeping count (Ibid.). The number of egg masses laid in the Poe reach varies substantially year-to-year from a low of 26 in 2001 to a high of 154 in 2015 and back down to 36 in 2017 (GANDA 2018).

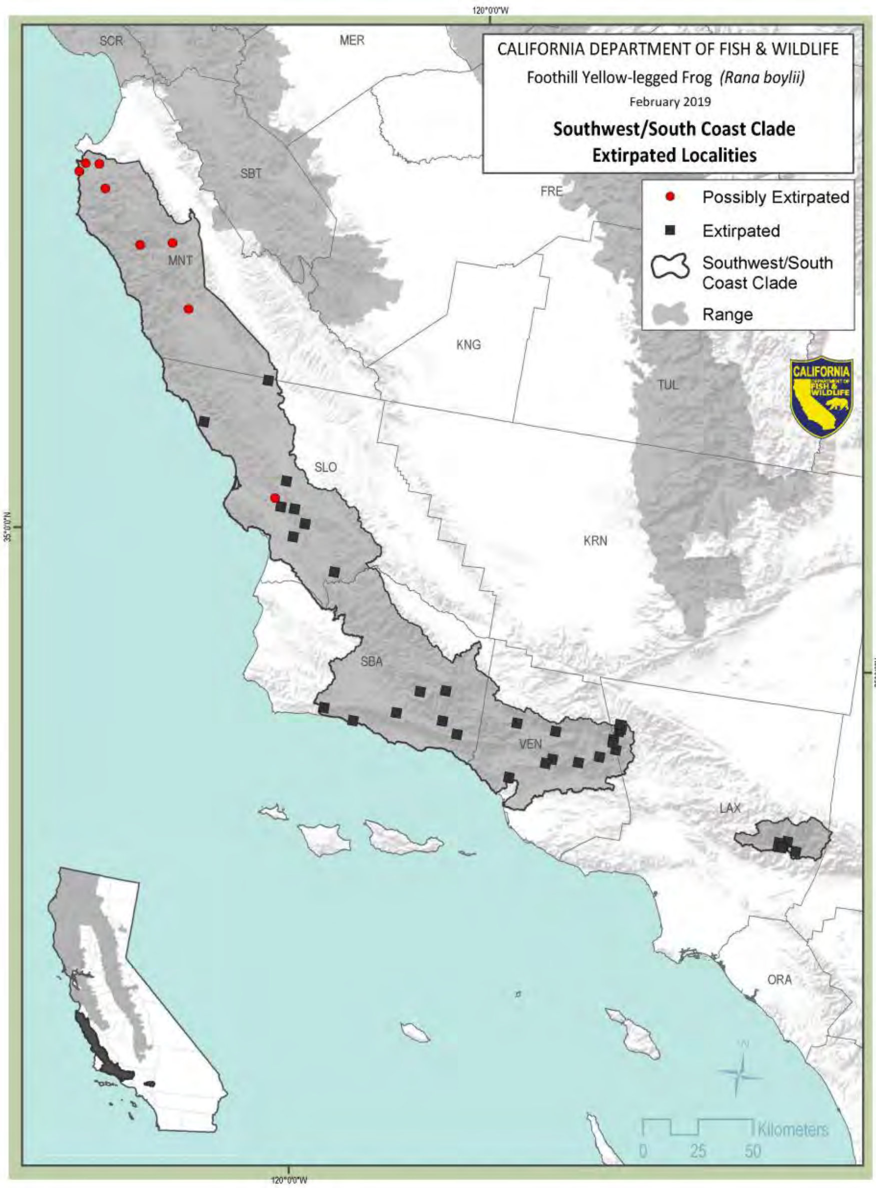

Figure 11. Possibly extirpated and extirpated Southwest/South Coast Foothill Yellow-legged Frog clade sites (CNDDB)

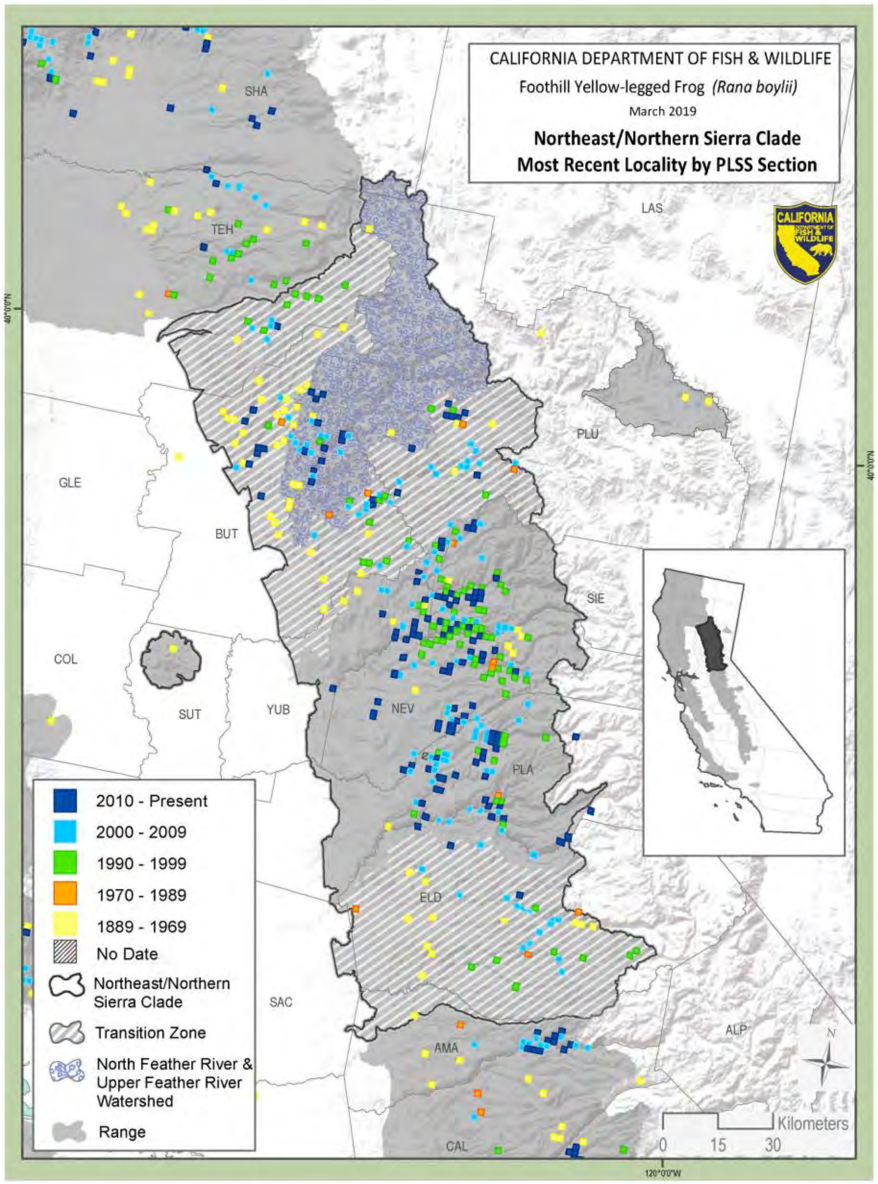

Figure 12. Close-up of Northeast/Feather River and Northern Sierra clades observations from 1889-2019 (ARSSC, BIOS, CNDDB)

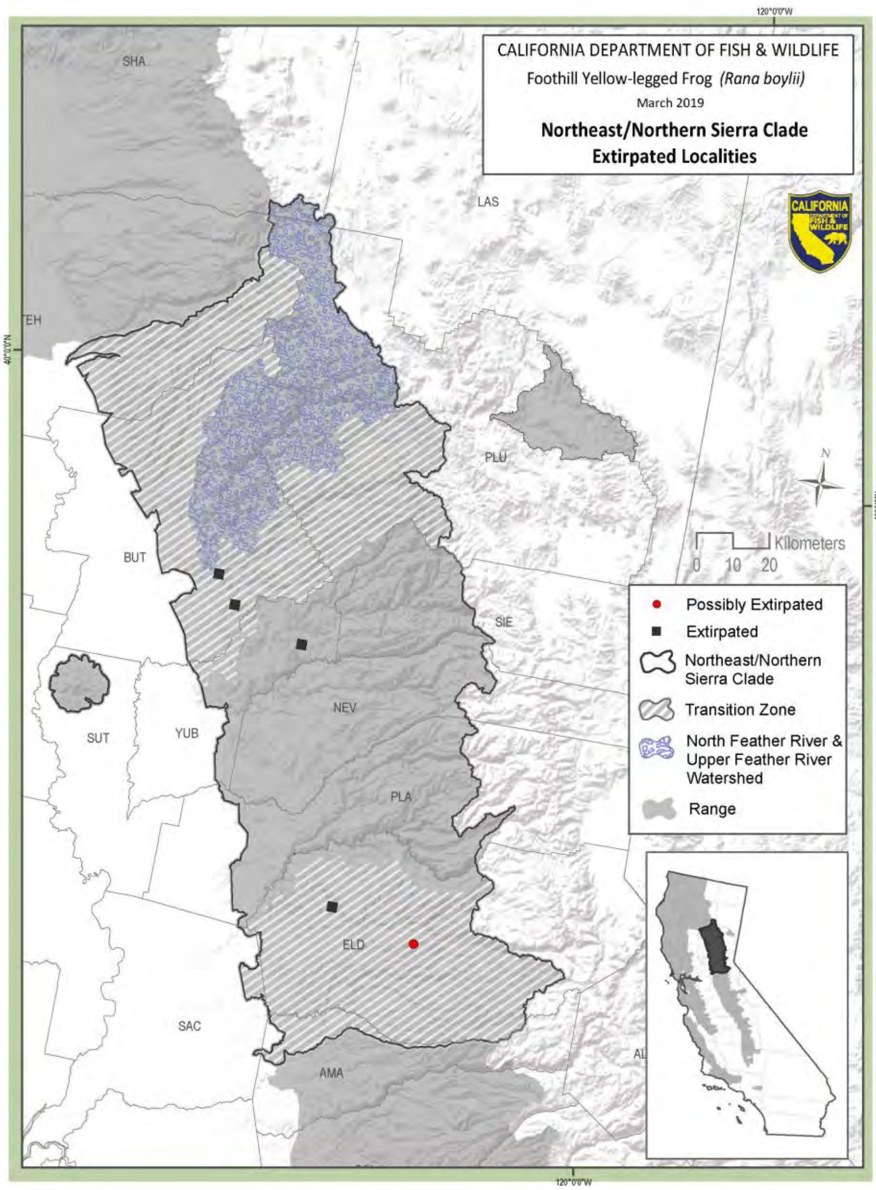

Figure 13. Possibly extirpated and extirpated Northeast/Feather River and Northern Sierra Foothill Yellow-legged Frog clades sites (CNDDB)

Foothill Yellow-legged Frogs have been observed in at least 71 areas in the past 5 years in the presumptive Northeast/Northern Sierra clade. The general pattern in this clade, and across the range ~~for that matter~~, is that unregulated rivers or reaches have more areas that are occupied more consistently and in larger numbers than regulated rivers or reaches (CNDDB 2019, S. Kupferberg pers. comm. 2019). Foothill Yellow-legged Frogs were rarely observed in the hydropeaking reach of the Middle Fork American River and were observed in low numbers in the bypass reach, but they were present and breeding in small tributary populations (PCWA 2008). Relatively robust populations appear to inhabit the North Fork American River and Lower Rubicon River (Gaos and Bogan 2001, PCWA 2008, Hogan and Zuber 2012, K. Kundargi pers. comm. 2014, S. Kupferberg pers. comm. 2019). Additional apparently sufficiently large and relatively stable populations occur on Clear Creek, South Fork Greenhorn Creek, and Shady Creek (Nevada County) and the North and Middle Yuba River (Sierra County), but the remaining observations are of small numbers in tributaries with minimal connectivity among them (CNDDB 2019, S. Kupferberg pers. comm. 2019).

East/Southern Sierra

The East/Southern Sierra clade is presumed to range from the South Fork American River watershed, the northernmost site where individuals from this clade were collected, south to where the Sierra Nevada meets the Tehachapi Mountains. It likely includes El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, Fresno, Tulare, and Kern counties (Figure 14; Peek 2018). The proportion of extirpated sites in this clade is second only to the Southwest/South Coast and follows the pattern of greater losses in the south (Figure 15). Like the southern coastal clade, the southern Sierra clade has low genetic variability and a trajectory of continued loss of diversity (Ibid.).

Historical collections of small numbers of Foothill Yellow-legged Frogs occurred in every major river system within this clade beginning as early as the turn of the 20th century, indicating widespread distribution but little information on abundance (Hayes et al. 2016). By the early 1970s, declines in Foothill Yellow-legged Frog populations from this area were already apparent; Moyle (1973) found them at 30 of 95 sites surveyed in 1970. Notably bullfrogs inhabited the other 65 sites formerly occupied by Foothill Yellow-legged Frogs, and they co-occurred at only 3 sites (Ibid.). In 1992, Drost and Fellers (1996) revisited the sites around Yosemite National Park (Tuolumne and Mariposa counties) that Grinnell and Storer (1924) surveyed in 1915 and 1919. Foothill Yellow-legged Frogs had disappeared from all seven historically occupied sites and were not found at any new sites surveyed surrounding the park (Ibid.). Resurveys of previously occupied sites on the Stanislaus (Tuolumne County), Sierra (Fresno County), and Sequoia (Tulare County) National Forests were also undertaken (Lind et al. 2003b). Foothill Yellow-legged Frogs were absent from the sites in Sierra and Sequoia National Forests, six at each forest; however, a new population was discovered in the Sierra and two in the Sequoia forests (Ibid.). These populations remain extant but are small and isolated (CNDDB 2019). Two of the six sites on the Stanislaus were still occupied, and 19 new populations were found with evidence of breeding at seven of them (Lind et al. 2003b). Twenty of the 24 populations extant at the time inhabited unregulated waterways (Ibid.). Most of the CNDDB (2019) records of Foothill Yellow-legged Frogs on the Stanislaus are at least a decade old and are represented by low numbers.

Commented [RAP9]: May want to clarify this a bit…sites or frogs? I'd split into a separate sentence specifying that frogs were absent from 6 sites in each forest…can't hurt to be explicit.

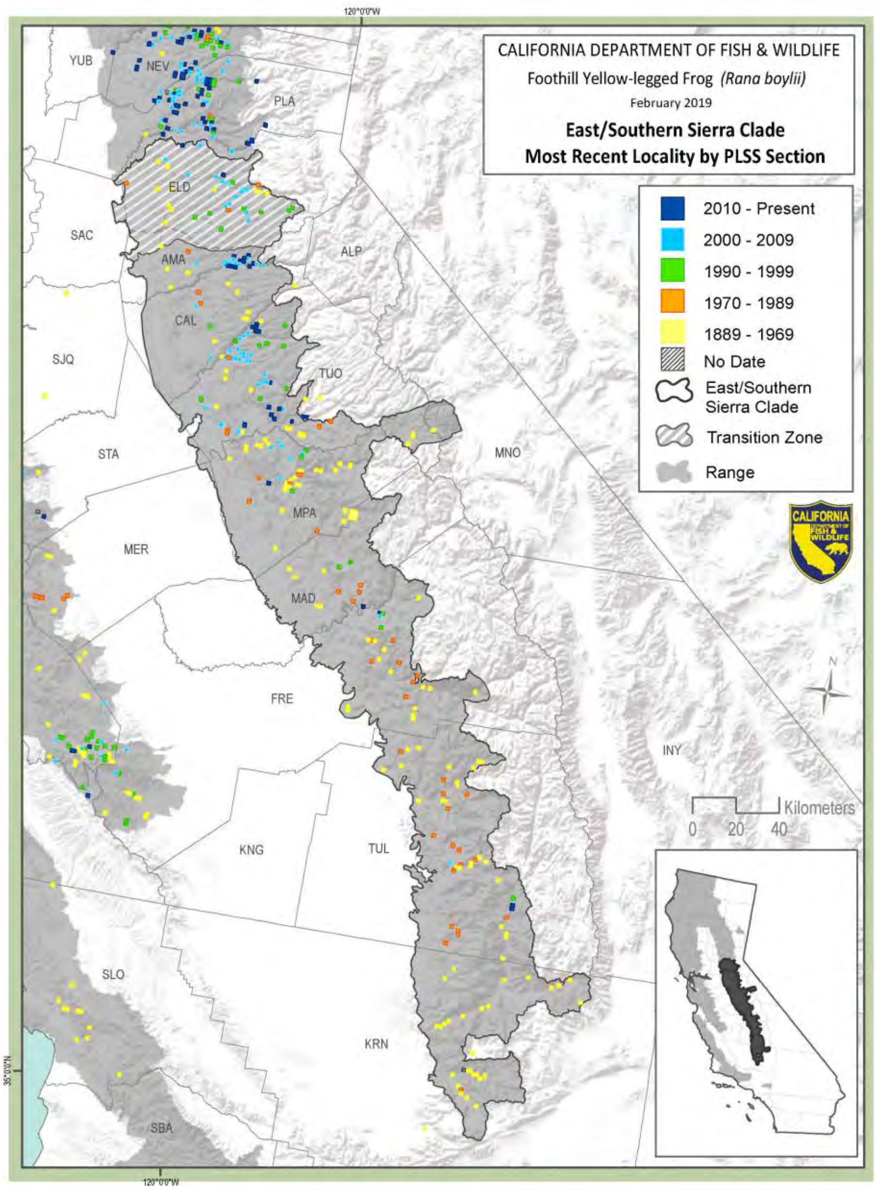

Figure 14. Close-up of East/Southern Sierra clade observations from 1889-2019 (ARSSC, BIOS, CNDDB)

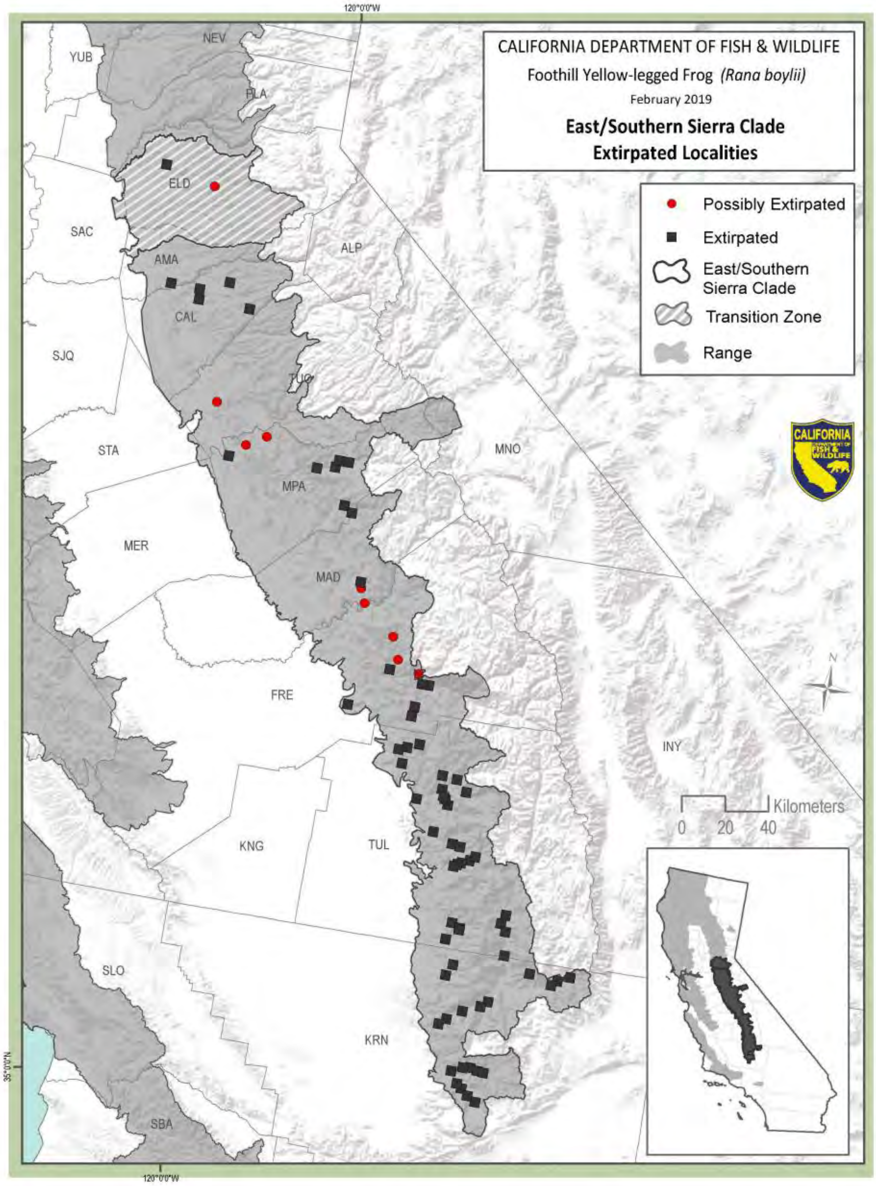

Figure 15. Possibly extirpated and extirpated East/Southern Sierra Foothill Yellow-legged Frog clade sites (CNDDB)

More recently, surveys for Foothill Yellow-legged Frogs were conducted along the South Fork American River as part of the El Dorado Hydroelectric Project's FERC license amphibian monitoring requirements (GANDA 2017). Between 2002 and 2016 counts of different life stages varied significantly by year but the trend for every life stage was a decline over that period (Ibid.). There appears to be a small population persisting along the North Fork Mokelumne River (Amador and Calaveras counties), but it was only productive during the 2012-2014 drought years (Ibid.). Small numbers have also been observed recently in several locations on private timberlands in Tuolumne County (CNDDB 2019).

FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

"The fortunes of the boylii *population fluctuate with those of the stream"* - Tracy I. Storer, 1925

Several past and ongoing activities have changed the watersheds upon which Foothill Yellow-legged Frogs depend, and many interact with each other exacerbating their adverse impacts. With such an expansive range in California, the degree and severity of these impacts on the species often vary by location. To the extent feasible based on the best scientific information available, those differences are discussed below.

Dams, Diversions, and Water Operations

Foothill Yellow-legged Frogs evolved in a Mediterranean climate with predictable cool, wet winters and hot, dry summers, with their life cycle is adapted to these conditions. In California and other areas with a Mediterranean climate, human demands for water are at the highest when runoff and precipitation are lowest, and annual water supply varies significantly but always follows the general pattern of peak discharge declining to baseflow in the late spring or summer (Grantham et al. 2010). The Foothill Yellow-legged Frog's life cycle depends on this ~~discharge~~ flow pattern and the specific habitat conditions it produces (see the Breeding and Rearing Habitat section). Dams are ubiquitous, but not evenly distributed, in California. Figure 16 depicts the locations of dams under the jurisdiction of the Army Corps of Engineers (ACOE) and the California Department of Water Resources (DWR). Figure 17 depicts the number of surface diversions per PLSS section within the Foothill Yellow-legged Frog's range (eWRIMS 2019).

Dam operations frequently change the amount, ~~and~~ timing, and frequency of water availability; its temperature, depth, and velocity; and its sediment transport and channel morphology altering functions, which can result in dramatic consequences on the Foothill Yellow-legged Frog's ability to survive and successfully reproduce. Several studies comparing Foothill Yellow-legged Frog populations in regulated and unregulated reaches within the same watershed investigate potential dam-effects. These studies demonstrated that dams and their operations can result in several factors that contribute to population declines and possible extirpation. These factors include confusing breeding cues, scouring and stranding of egg masses and tadpoles, reduced quality and quantity of breeding and rearing habitat, reduced tadpole growth rate, barriers to gene flow, and establishment and spread of non-native species (Hayes et al. 2016). In addition, as previously discussed in the Population Structure and Genetic Diversity section, subpopulations of Foothill Yellow-legged Frogs on regulated rivers are more genetically isolated, and the

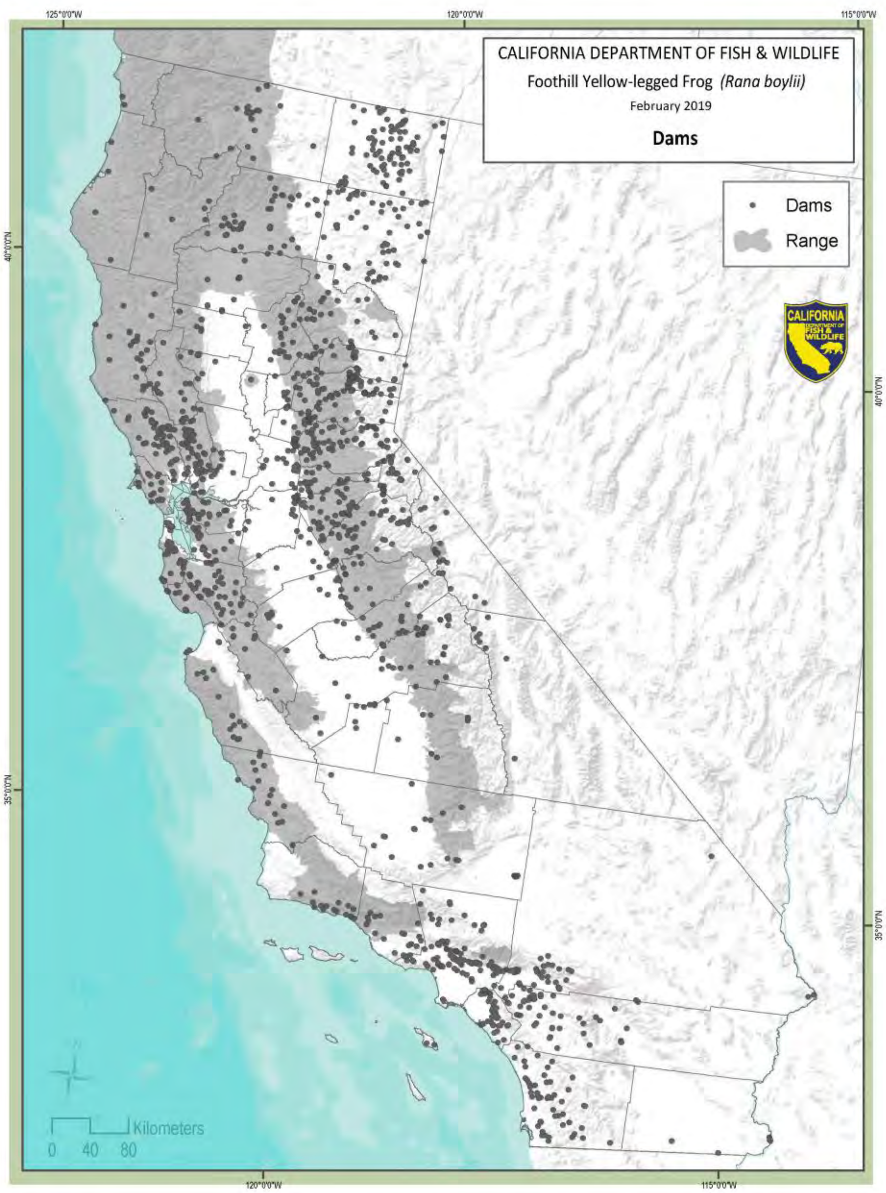

Figure 16. Locations of ACOE and DWR jurisdictional dams (DWR, FRS)

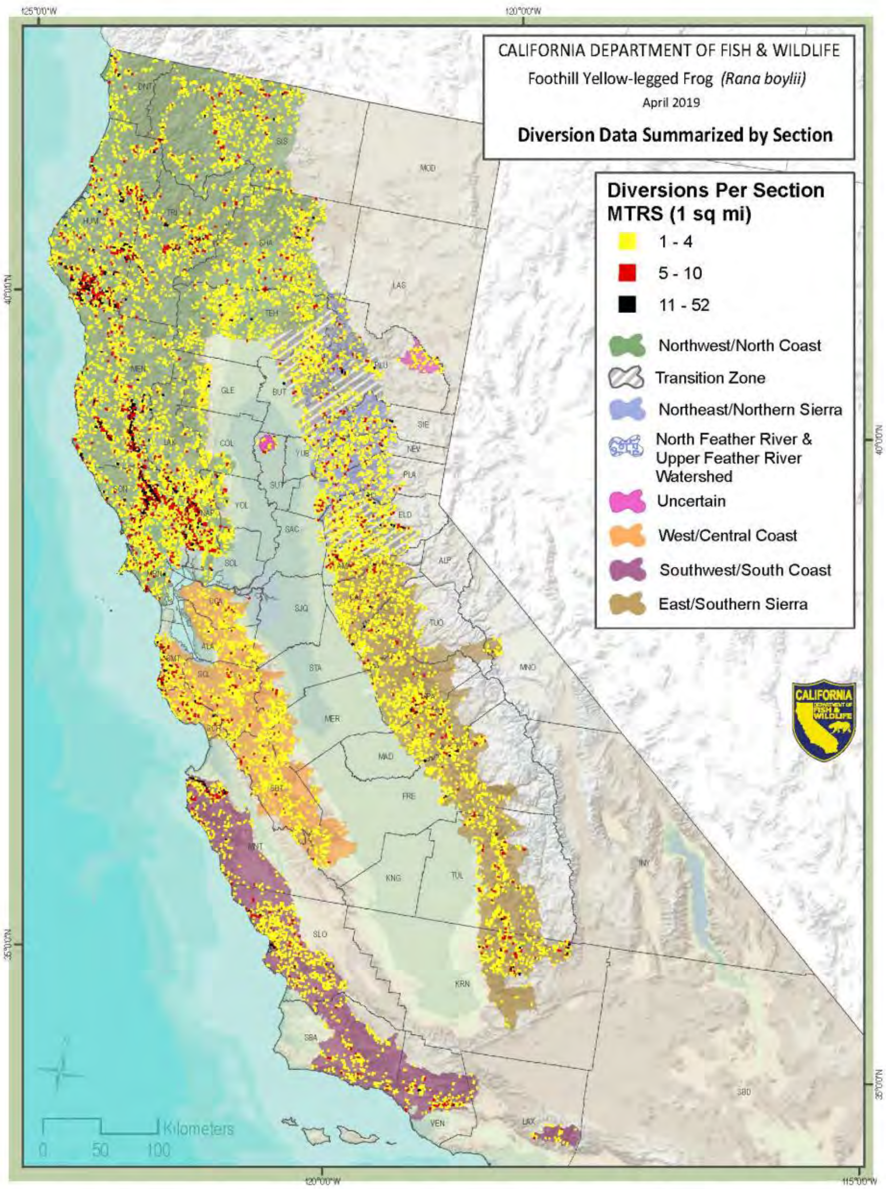

Figure 17. Number of surface water diversions per Public Lands Survey System section within the Foothill Yellow-legged Frog's range in California (eWRIMs)

type of water operations (hydropeaking vs. bypass flows) significantly affects the degree of connectivity and associated gene flow loss among them (Peek 2010~~1~~, 2018). Figure 18 depicts the locations of hydroelectric power plants.

As discussed in the Seasonal Activity and Movements section, cues for Foothill Yellow-legged Frogs to start breeding ~~appear~~ include~~to involve~~ water temperature and velocity, two features altered by dams. Dam operations typically result in reduced flows that are more stable over the course of a year than unimpaired conditions, and dam managers are frequently required to maintain thermally appropriate water temperatures and flows for cold-water-adapted salmonids (USFWS and Hoopa Valley Tribe 1999, Wheeler et al. 2014). For example, late-spring and summer water temperatures on the mainstem Trinity River below Lewiston Dam have been reported to be up to 10°C (20°F) cooler than average pre-dam temperatures, while average winter temperatures are slightly warmer (USFWS and Hoopa Valley Tribe 1999). As a result, Foothill Yellow-legged Frogs breed later on the mainstem Trinity River compared to six nearby tributaries, and some mainstem reaches may never attain the minimum required temperature for breeding (Wheeler et al. 2014, Snover and Adams 2016). In addition, annual discharges past Lewiston Dam have been 10-30% of pre-dam flows and do not mimic the natural hydrograph (Lind et al. 1996).

Aseasonal discharges from dams occur for several reasons including increased flow in late-spring and early summer to facilitate outmigration of salmonids, channel maintenance pulse flows, short-duration releases for recreational whitewater boating, rapid reductions after a spill (uncontrolled flows released down a spillway when reservoir capacity is exceeded) to retain water for power generation or water supply later in the year, peaking flows for hydroelectric power generation, and sustained releases to maintain the seismic integrity of the dam (Lind et al. 1996, Jackman et al. 2004, Kupferberg et al. 2011b, Kupferberg et al. 2012, Snover and Adams 2016). The results of a Foothill Yellow-legged Frog population viability analysis (PVA) suggest that the likelihood a population will persist is very sensitive to early life stage mortality; the 30-year probability of extinction increases significantly with high levels of egg or tadpole scouring or stranding (Kupferberg et al. 2009c). For instance, in 1991 and 1992, all egg masses laid before high flow releases to encourage outmigration of salmonids on the Trinity River were scoured away (Lind et al. 1996). According to the PVA, even a single annual pulse flow such as this or for recreational boating, can result in a three- to five-fold increase in the 30-year extinction risk based on amount of tadpole mortality experienced (Kupferberg et al. 2009c). Management after natural spills can also lead to substantial mortality. For example, in 2006, Foothill Yellow-legged Frogs on the North Fork Feather River bred during a prolonged spill, and the rapid recession below Cresta Dam that followed stranded and desiccated all the eggs laid (Kupferberg et al. 2009b). Rapid flows can also increase predation risk if tadpoles are forced to seek shelter under rocks where crayfish and other invertebrate predators are more common or if they are displaced into the water column where their risk of predation by fish is greater (Ibid.).

Commented [RAP10]: I think while this is true, it's also true that dams also artificially elevate flows over the course of the year (impaired summer baseflows are often much higher than natural flows), and they also can have much more aseasonal variability (i.e., hydropeaking). So here I'd rephrase/restructure this to focus more on the fact that flow regulation impairs natural patterns of flow variability and predictability/seasonality. You could mention the examples above or keep it broad…but I could see the "typically result in reduced flows that are more stable" comment as something that could be misconstrued or misused if taken by itself.

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The overall reduction of flows and frequency of large winter floods below dams can produce extensive changes to Foothill Yellow-legged Frog habitat quality. They reduce the formation of river bars that are regularly used as breeding habitat, and they create deeper and steeper channels with less complexity and fewer warm, calm, shallow edgewater habitats for tadpole rearing (Lind et al. 1996, Wheeler and Welsh 2008, Kupferberg et al. 2011b, Wheeler et al. 2014). For example, 26 years after construction of

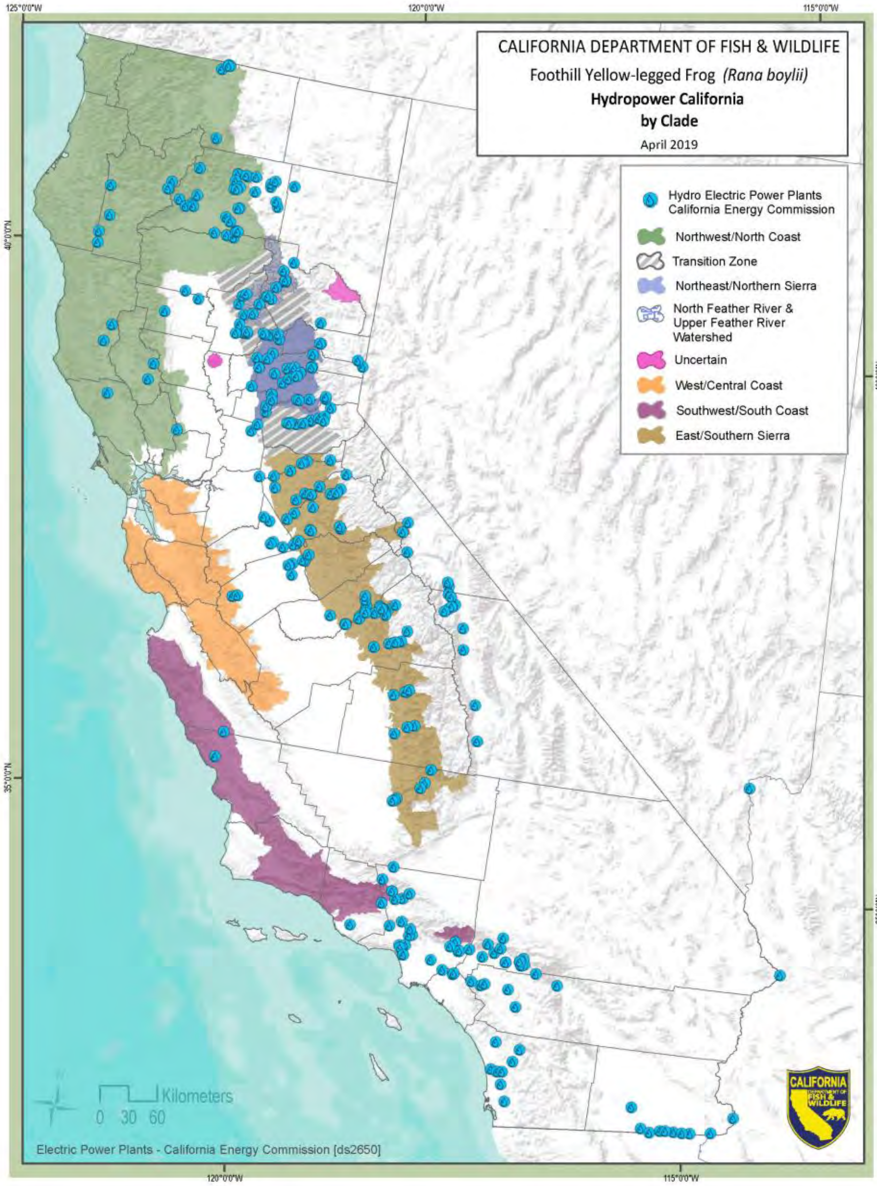

Figure 18. Locations of hydroelectric power generating dams (BIOS)

the Lewiston Dam on the Trinity River, habitat changes in a 63 km (39 mi) stretch from the dam downstream were evaluated (Lind et al. 1996). Riparian vegetation went from covering 30% of the riparian area pre-dam to 95% (Ibid.). Additionally, river bars made up 70% of the pre-dam riparian area compared to 4% post-dam, amounting to a 94% decrease in available Foothill Yellow-legged Frog breeding habitat (Ibid.).

Several features of riverine habitat below dams can decrease tadpole growth rate and other measures of fitness. As ectotherms, Foothill Yellow-legged Frogs require temperatures that support their metabolism, food conversion efficiency, growth, and development, and these temperatures may not be reached until late in the season, or not at all, when the water released is colder than their lower thermal limit (Kupferberg et al. 2011a, Catenazzi and Kupferberg 2013, Wheeler et al. 2014). Colder temperatures and higher flows reduce time spent feeding and efficiency at food assimilation, resulting in slower growth and development (Kupferberg et al. 2011a,b; Catenazzi and Kupferberg 2018). Large bed-scouring winter floods promote greater *Cladophora glomerate* blooms, the filamentous green alga that dominates primary producer biomass during the tadpole rearing season (Power et al. 2008, Kupferberg et al. 2011a). The period of most rapid tadpole growth often coincides with blooms of highly nutritious and more easily assimilated epiphytic diatoms, so reduced flows can have food-web impacts on tadpole growth and survival (Power et al. 2008, Kupferberg et al. 2011a, Catenazzi and Kupferberg 2018). In addition, colder temperatures and fluctuating summer flows, such as those released for hydroelectric power generation, can reduce the amount of algae available for grazing and can change the algal assemblage to one dominated by mucilaginous stalked diatoms like *Didymosphenia geminate* that have low nutritional value (Spring Rivers Ecological Sciences 2003, Kupferberg et al 2011a, Furey et al. 2014). Altered temperatures, flows, and food quality can contribute to slower growth and development, longer time to metamorphosis, smaller size at metamorphosis, and reduced body condition, which adversely impact fitness (Kupferberg et al. 2011b, Catenazzi and Kupferberg 2018).

As discussed in more detail in the Population Structure and Genetic Diversity section, both are strongly affected by river regulation (Peek 20101, 2018; Stillwater Sciences 2012). Foothill Yellow-legged Frogs primarily use watercourses as movement corridors, so the reservoirs created behind dams are often uninhabitable and represent barriers to gene flow (Bourque 2008; Peek 20101, 2018). This decreased connectivity can lead to loss of genetic diversity, ~~inducing~~ which can reduce a species' ability to adapt to changing conditions (Palstra and Ruzzante 2008).

Decreased winter discharge below dams facilitates establishment and expansion of invasive bullfrogs, whose tadpoles require overwintering and are not well-adapted to flooding events (Lind et al. 1996, Doubledee et al. 2003). Where they occur, bullfrogs tend to dominate areas more altered by dam operations than less impaired areas that support a higher proportion of native species (Moyle 1973, Fuller et al. 2011). In addition to downstream effects, ~~the~~ reservoirs ~~created~~ behind dams directly inundate and eliminate ~~destroy~~ lotic (flowing) Foothill Yellow-legged Frog habitat, typically do not retain natural riparian communities due to fluctuating water levels, are often managed for human activities not compatible with the species' needs, and act as a source of introduced species upstream and downstream (Brode and Bury 1984, PG&E 2018). Moyle and Randall (1998) identified characteristics of sites with low native biodiversity in the Sierra Nevada foothills; they were often drainages that had been

Commented [RAP12]: Could cite the 2013 CEC report that Sarah Yarnell & others did on spring recession characterization in reg/unreg rivers, we have figures/data showing algal abundance/biomass in the MF American and SF Yuba was extremely high and was driven by didymo growth. (https://www.energy.ca.gov/2014publications/CEC-500-2014-030/CEC-500-2014-030.pdf)
Yarnell, S. M., Peek, R. A., Rheinheimer, D. E., Lind, A. J., & Viers, J. H. (2013). *Management of the Spring Snowmelt Recession: An Integrated Analysis of Empirical, Hydrodynamic, and Hydropower Modeling Applications* (No. CEC-500-2014-030; Vol. CEC-500–2014–2030). California Energy Commission, PIER.

dammed and diverted in lower- to middle-elevations and dominated by introduced fishes and bullfrogs. Even small-scale operations can have significant effects. Some farming operations divert water during periods of high flows and store it in small impoundments for use during low flow-high ~~need~~ demand times; these ponds can serve as sources for introduced species like bullfrogs to spread into areas where the habitat would otherwise be unsuitable (Kupferberg 1996b).

The mechanisms described above result in the widespread pattern of greater Foothill Yellow-legged Frog density in unregulated rivers and in reaches far enough downstream of a dam to experience minimal effects from it (Lind et al. 1996, Kupferberg 1996a, Bobzien and DiDonato 2007, Peek 2010~~1~~). Abundance of Foothill Yellow-legged Frogs in unregulated rivers averages five times greater than population abundance downstream of large dams (Kupferberg et al. 2012). Figure 19 depicts a comprehensive collection of egg mass density data where at least four years of surveys have been undertaken, showing much lower abundance in regulated (S. Kupferberg pers. comm. 2019). In California, Foothill Yellow-legged Frog presence is associated with an absence of dams or with only small dams far upstream (Lind 2005, Kupferberg et al. 2012). Hydroelectric power generation from Sierra Nevada rivers accounts for nearly half its statewide production and about 9% of all electrical power used in California (Dettinger et al. 2018). Every major stream below 600 m (1968 ft) in the Sierra Nevada has at least one large reservoir (≥ 0.12 km^3 [100,000 ac-ft]), and many have multiple medium and small ones (Hayes et al. 2016). Because of this, Catenazzi and Kupferberg (2017) posit that the dam-effect on Foothill Yellow-legged Frog populations is likely greater in the Sierra Nevada than the Coast Range because dams are more often constructed in a series along a river in the former and spaced close enough together such that suitable breeding temperatures may never occur in the intervening reaches.

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Pathogens and Parasites

Perhaps the most widely recognized amphibian disease is chytridiomycosis, which is caused by the fungal pathogen *Batrachochytrium dendroabatidis* (Bd). Implicated in the decline of over 500 amphibian species, including 90 presumed extinctions, it represents the greatest recorded loss of biodiversity attributable to a disease (Scheele et al. 2019). The global trade in American Bullfrogs (primarily for food) is connected to the disease's spread because the species can persist with low-level Bd infections without developing chytridiomycosis (Yap et al. 2018). Previous studies suggested Foothill Yellow-legged Frogs may not be susceptible to Bd-associated mass mortality; skin peptides strongly inhibited growth of the fungus in the lab, and the only detectable difference between Bd+ and Bd- juvenile Foothill Yellow-legged Frogs was slower growth (Davidson et al. 2007). At Pinnacles National Park in 2006, 18% of post-metamorphic Foothill Yellow-legged Frogs tested positive for Bd; all were asymptomatic and at least one Bd+ Foothill Yellow-legged Frog subsequently tested negative, demonstrating an ability to shed the fungus (Lowe 2009). However, recent studies have found historical evidence of Bd contributing to the extirpation of Foothill Yellow-legged Frogs in southern California, an acute die-off in 2013 in the Alameda Creek watershed, and another in 2018 in Coyote Creek (Adams et al. 2017a,b; Kupferberg and Catenazzi 2019). Evaluation of museum specimens indicates lower Bd prevalence (proportion of individuals infected) in Foothill Yellow-legged Frogs than most other co-occurring amphibians in southern California in the first part of the 20th century, but it spiked in the 1970s just prior to the last observation of an individual in 1977 (Adams et al. 2017b). Two museum specimens collected in 1966,

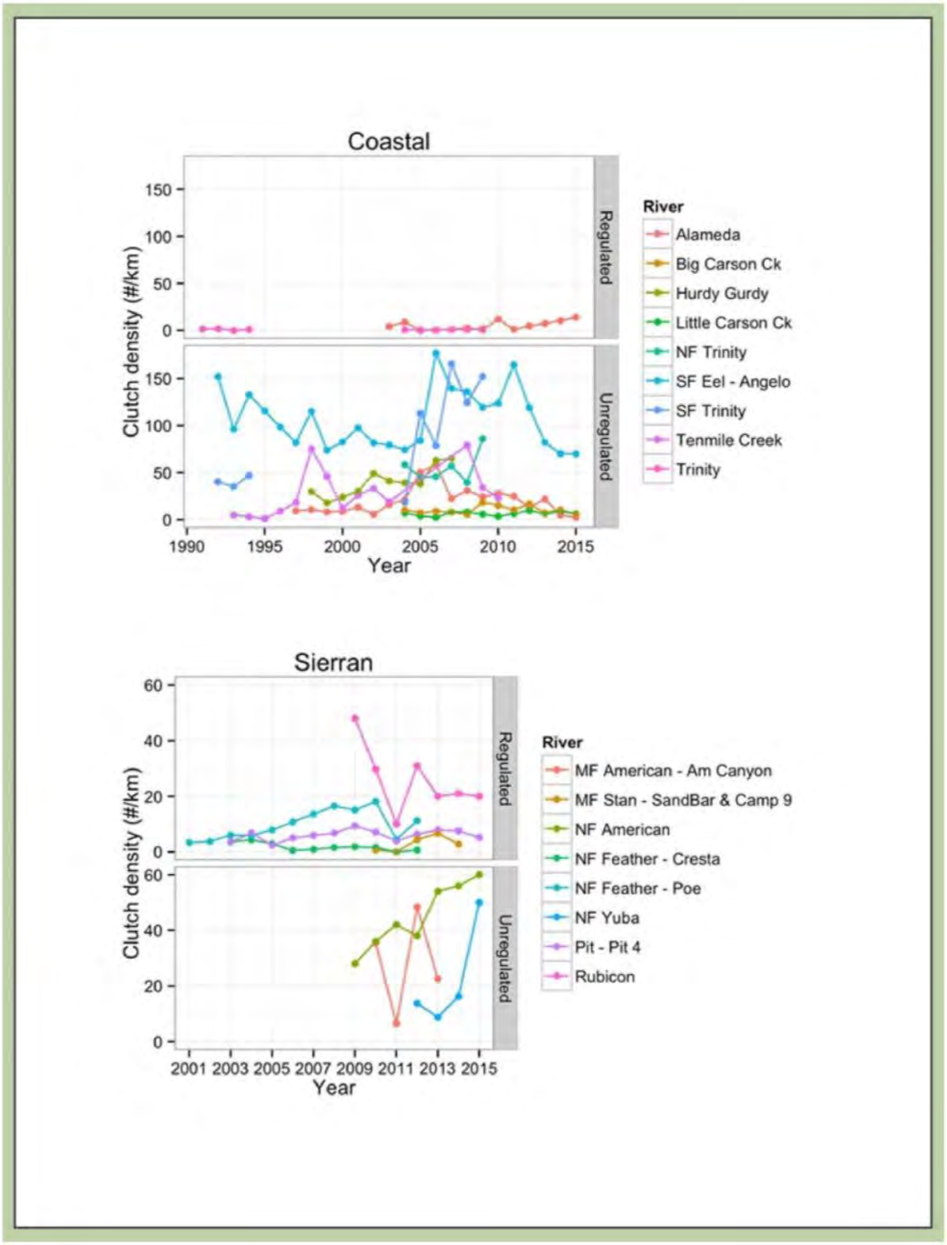

Figure 19. Foothill Yellow-legged Frog Egg mass density estimates along the coast from 1990-2015 and the Sierra Nevada from 2001-2015 from multiple studies compiled by R. Peek and S. Kupferberg (2019)

Commented [RAP14]: See comment in figure list at top, I'd cite this as Peek and Kupferberg 2016 (this is the figure we made for the poster)

one from Santa Cruz County and the other from Alameda County, provide the earliest evidence of Bd in Foothill Yellow-legged Frogs in central California (Padgett-Flohr and Hopkins 2009). In contrast to the southern California results, Foothill Yellow-legged Frogs possessed the highest Bd prevalence among all amphibians tested in coastal Humboldt County in 2013 and 2014; however, zoospore (the aquatic dispersal agent) loads were well below the presumed lethal density threshold (Ecoclub Amphibian Group et al. 2016).

In addition to bullfrogs, the native Pacific Treefrog (*Pseudacris regilla*) seems immune to the lethal effects of chytridiomycosis, and owing to its broad ecological tolerances, more terrestrial lifestyle, and relatively large home range size and dispersal ability, the species is ubiquitous across California (Padgett-Flohr and Hopkins 2009). In a laboratory experiment, Bd-infected Pacific Treefrogs shed an average of 68 zoospores per minute, making them the prime candidate for spreading and maintaining Bd in areas where bullfrogs do not occur (Padgett-Flohr and Hopkins 2009, Reeder et al. 2012). In the wild, Pacific Treefrog populations persisted at 100% of sites in the Sierra Nevada (above 1500 m [4920 ft]) where a sympatric ranid species had been extirpated from 72% of its formerly occupied sites due to a Bd outbreak (Reeder et al. 2012). This is consistent with the results of a model that incorporated Bd habitat suitability, host availability, and invasion history in North America, which concluded west coast mountain ranges were at the greatest risk from the disease (Yap et al. 2018).

Several other pathogens and parasites have been encountered with Foothill Yellow-legged Frogs, but none have been ascribed to large-scale mortality events. Another fungus, a water mold (*Saprolegnia* sp.) carried by fish, is an important factor in amphibian embryo mortality in the Pacific Northwest (Blaustein et al. 1994, Kiesecker and Blaustein 1997). Fungal infections of Foothill Yellow-legged Frog egg masses, potentially from *Saprolegnia*, have been observed in the mainstem Trinity River (Ashton et al. 1997). *Saprolegnia* infection is more likely to occur in ponds and lakes, particularly if stocked by hatchery-raised fish into previously fishless areas and when frogs use communal oviposition sites, so it likely does not represent a major source of mortality in Foothill Yellow-legged Frogs (Blaustein et al. 1994, Kiesecker and Blaustein 1997). However, they may be more susceptible to *Saprolegnia* infection when exposed to other environmental stressors that compromise their immune defenses (Blaustein et al. 1994, Kiesecker and Blaustein 1997).

The trematode parasite *Ribeiroia ondatrae* is responsible for limb malformations in ranids (Stopper et al. 2002). *Ribeiroia ondatrae* was detected on a single Foothill Yellow-legged Frog during a study on malformations, but its morphology was normal (Kupferberg et al. 2009a). The results of the study instead linked malformations in Foothill Yellow-legged Frog tadpoles and young-of-year to the Anchor Worm (*Lernae cyprinacea*), a parasitic copepod from Eurasia (Ibid.). Prevalence of malformations was low, under 4% of the population in both years of study, but there was a pattern of infected individuals metamorphosing at a smaller size, which as previously mentioned can have implications on fitness (Ibid.). Three other species of helminths (parasitic worms) were encountered during the study (*Echinostoma* sp., *Manodistomum* sp., and *Gyrodactylus* sp.); their relative impact on their hosts is unknown, but at least one Foothill Yellow-legged Frog had 700 echinstome cysts in its kidney (Ibid.). Bursey et al. (2010) discovered 13 species of helminths in and on Foothill Yellow-legged Frogs from

Humboldt County. Most are common in anurans, and some are generalists with multiple possible hosts, but studies on their impact on Foothill Yellow-legged Frogs are lacking (Ibid.).

Introduced Species

Species not native to an area, but introduced, can alter food webs and ecosystem processes through predation, competition, hybridization, disease transmission, and habitat modification. Native species lack evolutionary history with introduced species, and early life stages of native anurans are particularly susceptible to predation by aquatic non-native species (Kats and Ferrer 2003). Because introduced species often establish in highly modified habitats, it can be difficult to differentiate between impacts from habitat degradation and the introduced species (Fisher and Shaffer 1996). However, native amphibians have been frequently found successfully reproducing in heavily altered habitats when introduced species were absent, suggesting introduced species themselves can impose an appreciable adverse effect (Ibid.). Numerous introduced species have been documented to adversely impact Foothill Yellow-legged Frogs or are suspected of doing so.

American Bullfrogs were introduced to California from the eastern U.S. around the turn of the 20th century, likely in response to overharvest of native ranids by the frog-leg industry that accompanied the Gold Rush (Jennings and Hayes 1985). Nearly 50 years ago, Moyle (1973) reported that distributions of Foothill Yellow-legged Frogs and bullfrogs in the Sierra Nevada foothills were nearly mutually exclusive. He speculated that bullfrog predation and competition may be causal factors in their disparate distributions in addition to the habitat degradation from dams and diversions that facilitated the bullfrog invasion in the first place. In a study along the South Fork Eel River and one of its tributaries, Foothill Yellow-legged Frog abundance was nearly an order of magnitude lower in reaches were bullfrogs were well established (Kupferberg 1997a). At a site in Napa Valley, after bullfrogs were eradicated, Foothill Yellow-legged Frogs, among other native species, recolonized the area (J. Alvarez pers. comm. 2018). In a mesocosm experiment, Foothill Yellow-legged Frog survival in control enclosures measured half that of enclosures containing bullfrog and Foothill Yellow-legged Frog tadpoles, and they weighed approximately one-quarter ~~lighter~~ less at metamorphosis (Kupferberg 1997a). The mechanism for these declines appeared to be the reduction of ~~high quality~~high-quality algae by bullfrog tadpole grazing, as opposed to any behavioral or chemical interference (Ibid.). Adult bullfrogs, which can get very large (9.0-15.2 cm [3.5-6.0 in]), also directly consume Foothill Yellow-legged Frogs, including adults (Moyle 1973, Crayon 1998, Powell et al. 2016). Silver (2017) noted that she never heard Foothill Yellow-legged Frogs calling in areas with bullfrogs, which has implications for breeding success; she speculated the lack of vocalizations may have been a predator avoidance strategy.

As discussed briefly in the Pathogens and Parasites section, American Bullfrogs act as reservoirs and vectors of the lethal chytrid fungus. In museum specimens from both southern and central California, Bd was detected in bullfrogs before it was detected in Foothill Yellow-legged Frogs in the same area (Padgett-Flohr and Hopkins 2009, Adams et al. 2017b). During a die-off from chytridiomycosis that commenced in 2013, Bd prevalence and load in Foothill Yellow-legged Frogs was positively predicted by bullfrog presence (Adams et al. 2017a). A similar die-off in 2018 from a nearby county appears to be related to transmission by bullfrogs as well (Kupferberg and Catenazzi 2019). In addition, male Foothill

Yellow-legged Frogs have been observed amplexing female bullfrogs, which may not only constitute wasted reproductive effort but could serve to increase their likelihood of contracting Bd (Lind et al. 2003a). In fact, adult males were more likely to be infected with Bd than females or juveniles during the recent die-off in Alameda Creek (Adams et al. 2017a). African Clawed Frogs (*Xenopus laevis*) have also been implicated in the spread of Bd in California because like bullfrogs, they are asymptomatic carriers (Padgett-Flohr and Hopkins 2009). However, African Clawed-Frog distribution only minimally overlaps with the Foothill Yellow-legged Frog's range unlike the widespread bullfrog (Stebbins and McGuinness 2012).

Hayes and Jennings (1986) observed a negative association between the abundance of introduced fish and Foothill Yellow-legged Frogs. Rainbow trout (*Onchorynchus mykiss*) and green sunfish (*Lepomis cyanellus*) are suspected of destroying egg masses (Van Wagner 1996). Bluegill sunfishes (*L. macrochirus*) are likely predators; in captivity when offered eggs and tadpoles of two ranid species, they consumed both life stages but a significantly greater number of tadpoles (Werschkul and Christensen 1977). Common hatchery-stocked fish like brook (*Salvelinus fontinalis*) and rainbow trout commonly carry of *Saprolegnia* (Blaustein et al. 1994). In addition, presence of non-native fish can facilitate bullfrog invasions by reducing the density of macroinvertebrates that prey on their tadpoles (Adams et al. 2003). Foothill Yellow-legged Frog tadpoles raised from eggs from sites with and without smallmouth bass (*Micropterus dolomieu*) did not differ in their responses to exposure to the non-native, predatory bass and a native, non-predatory fish (Paoletti et al. 2011). This result suggests that Foothill Yellow-legged Frogs have not yet evolved a recognition of bass as a threat, which makes them more vulnerable to predation (Ibid.).

Introduced into several areas within the Coast Range and Sierra Nevada, signal crayfish have been recorded preying on Foothill Yellow-legged Frog egg masses and are suspected of preying on their tadpoles based on observations of tail injuries that looked like scissor snips (Riegel 1959, Wiseman et al. 2005). The introduced red swamp crayfish (*Procambarus clarkii*) likely also preys on Foothill Yellow-legged Frogs. Because Foothill Yellow-legged Frogs evolved with native crayfish in northern California, individuals from those areas may more effectively avoid crayfish predation than in other parts of the state where they are not native (Riegel 1959, USFWS 1998, Kats and Ferrer 2003). The Foothill Yellow-legged Frog's naivety to crayfish was demonstrated in a study that showed they did not change behavior when exposed to signal crayfish chemical cues, but once the crayfish was released and consuming Foothill Yellow-legged Frog tadpoles, the survivors, likely reacting to chemical cues from dead tadpoles, did respond (Kerby and Sih 2015).

Sedimentation

Several anthropogenic activities, some of which are described in greater detail below, can artificially increase sedimentation into waterways occupied by Foothill Yellow-legged Frogs and adversely impact biodiversity (Moyle and Randall 1998). These activities include but are not limited to mining, agriculture, overgrazing, timber harvest, and poorly constructed roads (Ibid.). Increased fine sediments can substantially degrade Foothill Yellow-legged Frog habitat quality. Heightened turbidity decreases light penetration that phytoplankton and other aquatic plants require for photosynthesis (Cordone and Kelley

1961). When silt particles fall out of the water column, they can destroy algae by covering the bottom of the stream (Ibid.). Algae are not only important for Foothill Yellow-legged Frog tadpoles as forage but also oxygen production (Ibid.). Sedimentation may impede attachment of egg masses to substrate (Ashton et al. 1997). The effect of silt accumulation on embryonic development is unknown, but it does make them less visible, which could decrease predation risk (Fellers 2005). Fine sediments can fill interstitial spaces between rocks that tadpoles use for shelter from high velocity flows and cover from predators and that serve as sources for aquatic invertebrate prey for post-metamorphic Foothill Yellow-legged Frogs (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b).

Mining

Current mining practices, as well as legacy effects from historical mining operations, may adversely impact Foothill Yellow-legged Frogs through contaminants, direct mortality, habitat destruction and degradation, and behavioral disruption. While mercury in streams can result from atmospheric deposition, storm-induced runoff of naturally occurring mercury, agricultural runoff, and geothermal springs, runoff from historical mine sites mobilizes a significant amount of mercury (Foe and Croyle 1998, Alpers et al. 2005, Hothem et al. 2010). Beginning in the mid-1800s, extensive mining occurred in the Coast Range to supply mercury for gold mining in the Sierra Nevada, causing widespread contamination of both mountain ranges and the rivers in the Central Valley (Foe and Croyle 1998). Studies on Foothill Yellow-legged Frog tissues collected from the Cache Creek (Coast Ranges) and Greenhorn Creek (Sierra Nevada) watersheds revealed mercury bioaccumulation concentrations as high as 1.7 and 0.3 µg/g (ppm), respectively (Alpers et al. 2005, Hothem et al. 2010). For context, the U.S. Environmental Protection Agency's mercury criterion for issuance of health advisories for fish consumption is 0.3 µg/g; concentrations exceeded this threshold in Foothill Yellow-legged Frog tissues at 62% of sampling sites in the Cache Creek watershed (Hothem et al. 2010). Bioaccumulation of this powerful neurotoxin can cause deleterious impacts on amphibians including inhibited growth, decreased survival to metamorphosis, increased malformations, impaired reproduction, and other sublethal effects (Zillioux et al. 1993, Unrine et al. 2004). In a study measuring Sierra Nevada watershed health, Moyle and Randall (1998) reportedly found very low biodiversity in streams that were heavily polluted by acidic water leaching from historical mines. Acidic drainage measured as low as 3.4 pH from some mined areas in the northern Sierra Nevada (Alpers et al. 2005).

Widespread suction dredging for gold occurred in the Foothill Yellow-legged Frog's California range until enactment of a moratorium on issuing permits in 2009 (Hayes et al. 2016). Suction dredging vacuums up the contents of the streambed, passes them through a sluice box to separate the gold, and then deposits the tailings on the other side of the box (Harvey and Lisle 1998). While most habitat disturbance is localized and minor, it can be especially detrimental if it degrades or destroys breeding and rearing habitat through direct disturbance or sedimentation (Ibid.). In addition, this activity can lead to direct mortality of early life stages through entrainment, and those eggs and tadpoles that do survive passing through the suction dredge may experience greater mortality due to subsequent unfavorable physiochemical conditions and possible increased predation risk (Ibid.). Suction dredging can also reduce the availability of invertebrate prey, although this impact is typically short-lived (Ibid.). Suction dredging alters stream morphology, and relict tailing ponds can serve as breeding habitat for bullfrogs in areas

that would not normally support them (Fuller et al. 2011). However, in some areas these mining holes have reportedly benefited Foothill Yellow-legged Frogs by creating cool persistent pools that adult females appeared to prefer at one Sierra Nevada site (Van Wagner 1996). Senate Bill 637 (2015) directs the Department to work with the State Water Resources Control Board (SWRCB) to develop a statewide water quality permit that would authorize the use of vacuum or suction dredge equipment in California under conditions set forth by the two agencies. SWRCB staff, in coordination with Department staff, are in the process of collecting additional information to inform the next steps that will be taken by the SWRCB (SWRCB 2019).

Instream aggregate (gravel) mining continues today and can have similar impacts to suction dredge mining by removing, processing, and relocating stream substrates (Olson and Davis 2009). This type of mining typically removes bars used as Foothill Yellow-legged Frog breeding habitat and reduces habitat heterogeneity by creating flat wide channels (Kupferberg 1996a). Typically when listed salmonids are present, mining must be conducted above the wetted edge, but this practice can create perennial off-channel bullfrog breeding ponds (M. van Hattem pers. comm. 2018).

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Agriculture

Direct loss of Foothill Yellow-legged Frog habitat from wildland conversion to agriculture is rare because the typically rocky riparian areas they inhabit are usually not conducive to farming, but removal of riparian vegetation directly adjacent to streams for agriculture is more common and widespread. The U.S. Department of Agriculture classifies 3.9 million ha (9.6 million ac) in California as cropland, which amounts to less than 10% of the state's land area, and 70% of this occurs in the Central Valley between Redding and Bakersfield (Martin et al. 2018). In addition, several indirect impacts can adversely affect Foothill Yellow-legged Frogs at substantial distances from agricultural operations, such as effects from runoff (sediments and agrochemicals), drift and deposition of airborne pollutants, water diversions, and creation of novel habitats like impoundments that facilitate spread of detrimental non-native species. As sedimentation and introduced species impacts were previously discussed, this section instead focuses on the other possible adverse impacts.

Agrochemicals

Many species of amphibians, particularly ranids, have experienced declines throughout California, but the most dramatic declines have occurred in the Sierra Nevada east of the San Joaquin Valley where 60% of the total pesticide usage in the state was sprayed (Sparling et al. 2001). Agrochemicals applied to crops in the Central Valley can volatilize and travel in the atmosphere and deposit in higher elevations (LeNoir et al. 1999). Pesticide concentrations diminish as elevations increase in the lower foothills but change little from 533 to 1,920 m (1,750-6,300 ft), which coincides with the Foothill Yellow-legged Frog's elevational range (Ibid). Foothill Yellow-legged Frog absence at historically occupied sites in California significantly correlated with agricultural land use within 5 km (3 mi), and a positive relationship exists between Foothill Yellow-legged Frog declines and the amount of upwind agriculture, suggesting airborne agrochemicals may be a contributing factor (Figure 20; Davidson et al. 2002). Cholinesterase-inhibitors (most organophosphates and carbamates), which disrupt nerve impulse transmission, were

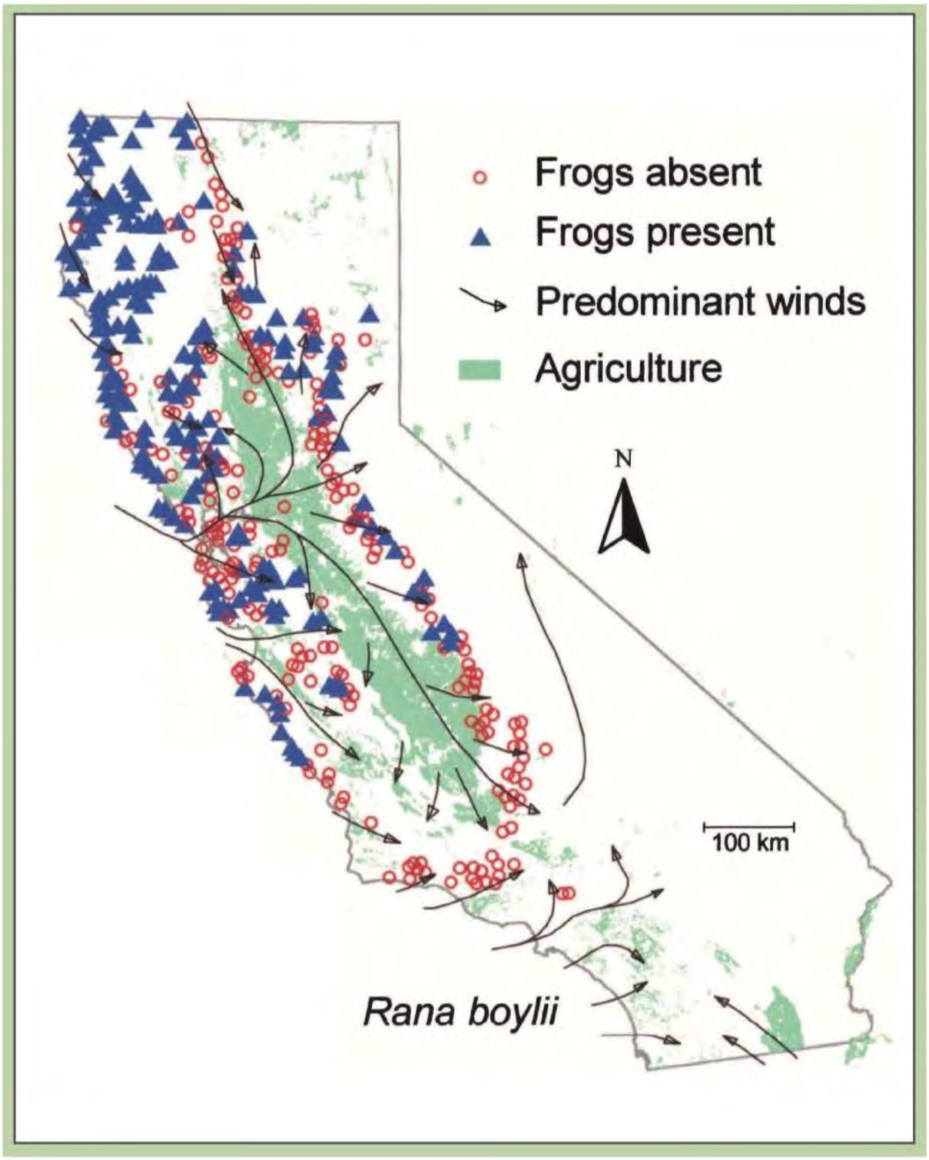

Figure 20. Relationship of Foothill Yellow-legged Frog occupancy to agriculture from Davidson et al. (2002)

more strongly associated with population declines than other pesticide types (Davidson 2004). Olson and Davis (2009) and Lind (2005) also reported a negative correlation between Foothill Yellow-legged Frog presence and proximity and quantity of nearby agriculture in Oregon and across the species' entire range, respectively.

Lethal and sublethal effects of agrochemicals on amphibians can take two general forms: direct toxicity and food-web effects. Sublethal doses of agrochemicals can interact with other environmental stressors to reduce fitness. Foothill Yellow-legged Frog tadpoles showed significantly greater vulnerability to the lethal and sublethal effects of carbaryl than Pacific Treefrogs (Kerby and Sih 2015). An inverse relationship exists between carbaryl concentration and Foothill Yellow-legged Frog activity, and their 72-h LC_{50} (concentration at which 50% die) measured one-fifth that of Pacific Treefrogs (Ibid.). Carbaryl slightly decreased Foothill Yellow-legged Frog development rate, but it significantly increased susceptibility to predation by signal crayfish despite nearly no mortality in the pesticide- and predator-only treatments (Ibid.). Sparling and Fellers (2009) also found Foothill Yellow-legged Frogs were significantly more sensitive to pesticides (chlorpyrifos and endosulfan in this study) than Pacific Treefrogs; their 96-hr LC_{50} was nearly five-times less than for treefrogs. Endosulfan was nearly 121 times more toxic to Foothill Yellow-legged Frogs than chlorpyrifos, and water samples from the Sierra Nevada have contained endosulfan concentrations within their lethal range and sometimes greater than the LC_{50} for the species (Ibid.). Sublethal effects included smaller body size, slower development rate, and increased time to metamorphosis (Ibid.). Sparling and Fellers (2007) determined the organophospates chlorpyrifos, malathion, and diazinon can harm Foothill Yellow-legged Frog populations, and their oxon derivatives (the resultant compounds once they begin breaking down in the body) were 10 to 100 times more toxic than their respective parental forms.

Extrapolating the results of studies on other ranids to Foothill Yellow-legged Frogs should be undertaken with caution; however, those studies can demonstrate additional potential adverse impacts of exposure to agrochemicals. Relyea (2005) discovered that Roundup®, a common herbicide, could cause rapid and widespread mortality in amphibian tadpoles via direct toxicity, and overspray at the manufacturer's recommended application concentrations would be highly lethal. Atrazine, another common herbicide, has been implicated in disrupting reproductive processes in male Northern Leopard Frogs (*Rana pipiens*) by slowing gonadal development, inducing hermaphroditism, and even oocyte (egg) growth (Hayes et al. 2003). However, recent research on sex reversal in wild populations of Green Frogs (*R. clamitans*) suggests it may be a relatively common natural process unrelated to environmental contaminants, requiring more research (Lambert et al. 2019). Malathion, a common organophosphate insecticide, that rapidly breaks down in the environment, applied at low concentrations caused a trophic cascade that resulted in reduced growth and survival of two species of ranid tadpoles (Relyea and Diecks 2008). Malathion caused a reduction in the amount of zooplankton, which resulted in a bloom of phytoplankton and an eventual decline in periphyton, an important food source for tadpoles (Ibid.). In contrast, Relyea (2005) found that some insecticides increased amphibian tadpole survival by reducing their invertebrate predators. Runoff from agricultural areas can contain fertilizers that input nutrients into streams and increase productivity, but they can also result in harmful algal blooms (Cordone and

Kelley 1961). In addition, exposure to pesticides can result in immunosuppression and reduce resistance to the parasites that cause limb malformations (Kiesecker 2002, Hayes et al. 2006).

Cannabis

An estimated 60-70% of the cannabis (*Cannabis indica* and *C. sativa*) used in the U.S. from legal and illegal sources is grown in California, and most comes from the Emerald Triangle, an area comprised of Humboldt, Mendocino, and Trinity counties (Ferguson 2019). Small-scale illegal cannabis farms have operated in this area since at least the 1960s but have expanded rapidly, particularly trespass grows on public land primarily by Mexican cartels, since the passage of the Compassionate Use Act in 1996 (Mallery 2010, Bauer et al. 2015). Like other forms of agriculture, it involves clearing the land, diverting water, and using herbicides and pesticides; however, in addition, many of these illicit operations use large quantities of fertilizers and highly toxic banned pesticides to kill anything that may threaten the crop, and they leave substantial amounts of non-biodegradable trash and human excrement (Mallery 2010, Thompson et al. 2014, Carah et al. 2015).

Measurements of environmental impacts of illegal cannabis grows have been hindered by the difficult and dangerous nature of accessing many of these sites; however, some analyses have been conducted, often using aerial images and geographic information systems (GIS). An evaluation of 54% of watersheds within and bordering Humboldt County revealed that while cannabis grow sites are generally small (< 0.5 ha [1.2 ac]) and comprised a tiny fraction of the study area (122 ha [301 ac]), they were widespread (present in 83% of watersheds) but unevenly distributed, indicating impacts are concentrated in certain watersheds (Butsic and Brenner 2016, Wang et al. 2017). The results also showed that 68% of grows were > 500 m (0.3 mi) from developed roads, 23% were located on slopes steeper than 30%, and 5% were within 100 m (328 ft) of critical habitat for threatened salmonids (Butsic and Brenner 2016). These characteristics suggest wildlands adjacent to cannabis cultivations are at heightened risk of habitat fragmentation, erosion, sedimentation, landslides, and impacts to waterways critical to imperiled species (Ibid.).

A separate analysis in the same general area estimated potentially significant impacts from water diversions alone. Cannabis requires a substantial amount of water during the growing season, so it is often cultivated near sources of perennial surface water for irrigation, commonly diverting from springs and headwater streams (Bauer et al. 2015). In the least impacted of the study watersheds, Bauer et al. (2015) calculated that diversions for cannabis cultivation could reduce the annual seven-day low flow by up to 23%, and in some of the heavily impacted watersheds, water demands for cannabis could exceed surface water availability. If not regulated carefully, cannabis cultivation could have substantial impacts on sensitive aquatic species like Foothill Yellow-legged Frogs in watersheds in which it is concentrated.

For context, cannabis cultivation was responsible for approximately 1.1% of forest cover lost within study watersheds in Humboldt County from 2000 to 2013, while timber harvest accounted for 53.3% (Wang et al. 2017). Cannabis requires approximately two times as much water per day as wine grapes, the other major irrigated crop in the region (Bauer et al. 2015). Impacts from cannabis cultivation have been observed by Foothill Yellow-legged Frog researchers working on the Trinity River and South Fork

Eel River in the form of lower flows in summer, increased egg stranding, and more algae earlier in the season in recent years (S. Kupferberg and M. Power pers. comm. 2015; D. Ashton pers. comm. 2017; S. Kupferberg, M. van Hattem, and W. Stokes pers. comm. 2017). In addition, Gonsolin (2010) reported illegal cannabis cultivations on four headwater streams that drained into his study area along Coyote Creek, three of which were occupied by Foothill Yellow-legged Frogs. The cultivators had removed vegetation adjacent to the creeks, terraced the slopes, diverted water, constructed small water impoundments, poured fertilizers directly into the impoundments, and applied herbicides and pesticides, as evidenced by leftover empty containers littering the site.

Commercial sale of cannabis for recreational use became legal in California on January 1, 2018, through passage of the Control, Regulate and Tax Adult Use of Marijuana Act (2016), and with it an environmental permitting system and habitat restoration fund was established. The number of applications for temporary licenses per watershed is depicted in Figure 21. Two of the expected outcomes of passage of this law were that the profit-margin on growing cannabis would fall to the point that it would discourage illegal trespass grows and move the bulk of the cultivation out of remote forested areas into existing agricultural areas like the Central Valley (CSOS 2016). However, until cannabis is legalized at the federal level, these results may not occur since banks are reluctant to work with growers due to federal prohibitions subjecting them to prosecution for money laundering (ABA 2019). Additional details on cannabis permitting at the state level can be found under the Existing Management section.

Vineyards

Vineyard operators historically built on-stream dams and removed almost all the riparian vegetation to make room for vines and for ease of irrigation (M. van Hattem pers. comm. 2019). They still divert a substantial amount of water for irrigation, and they build on- and off-stream impoundments that support bullfrogs (Ibid.). The acreage of land planted in wine grapes in California began rising dramatically in the 1970s and now accounts for 90% of wine produced in the U.S. (Geisseler and Horwath 2016, Alston et al. 2018). The number of wineries in California rose from approximately 330 to nearly 2,500 between 1975 and 2006; however, expansion slowed and has reversed slightly recently with 24,300 ha (60,000 ac), or 6.5% of total area planted, removed between 2015 and 2017 (Volpe et al. 2010, CDFA 2018). In 2015, 347,000 ha (857,000 ac) were planted in grapes with 70% located in the San Joaquin Valley; 66%, 21%, and 13% were planted in wine, raisin, and table grapes, respectively (Alston et al. 2018).

Expansion of wineries in the coastal counties converted natural areas such as oak woodlands and forests to vineyards (Merenlender 2000, Napa County 2010). The area of Sonoma County covered in grapes increased by 32% from 1990 to 1997, and 42% of these new vineyards were planted above 100 m (328 ft) with 25% on slopes greater than 18% (Merelender 2000). For context, only 18% of vineyards planted before 1990 occurred above 100 m (328 ft) and less than 6% on slopes greater than 18% (Ibid.). This conversion took place on approximately 773 ha (1,909 ac) of conifer and dense hardwood forest, 149 ha (367 ac) of shrubland, and 2,925 ha (7,229 ac) of oak grassland savanna (Ibid.).

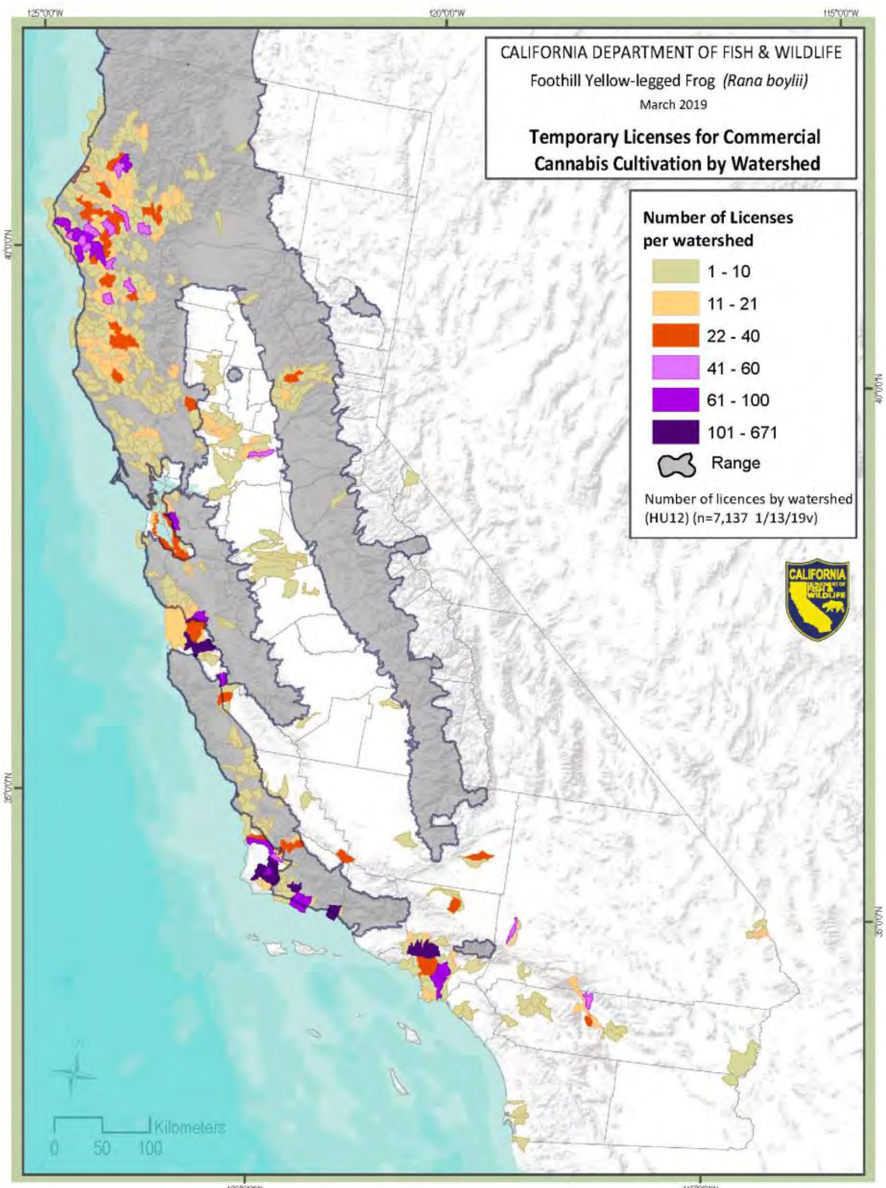

Figure 21. Cannabis cultivation temporary licenses by watershed in California (CDFA, NHD)

Recent expansion of oak woodland conversion to vineyards in Napa County was highest in its eastern hillsides (Napa County 2010). The County estimates that 1,085 and 1,240 ha (2,682-3,065 ac) of woodlands will be converted to vineyards between 2005 and 2030 (Ibid.). For context, 297 ha (733 ac) were converted from 1992 to 2003 (Ibid.). In addition, wine grapes were second only to almonds in terms of overall quantity of pesticides applied in California in 2016, but the quantity per unit area (2.9 kg/ha [2.6 lb/ac]) was 160% greater for the wine grapes (CDPR 2018). Vineyard expansion into hillsides has continued into sensitive headwater areas, and like cannabis cultivation, even small vineyards can have substantial impacts on Foothill Yellow-legged Frog habitat through sedimentation, water diversions, spread of harmful non-native species, and pesticide contamination (Merelender 2000, K. Weiss pers. comm. 2018).

Livestock Grazing

Livestock grazing can be an effective habitat management tool, including control of riparian vegetation encroachment, but overgrazing can significantly degrade the environment (Siekert et al. 1985). Cattle display a strong preference for riparian areas and have been implicated as a major source of habitat damage in the western U.S. where the adverse impacts of overgrazing on riparian vegetation are intensified by arid and semi-arid climates (Behnke and Raleigh 1978, Kauffman and Krueger 1984, Belsky et al. 1999). The severity of grazing impacts on riparian systems can be influenced by the number of animals, duration and time of year, substrate composition, and soil moisture (Benhke and Raleigh 1978, Kauffman et al. 1983, Marlow and Pogacnik 1985, Siekert et al. 1985). In addition to habitat damage, cattle can directly trample any life stage of Foothill Yellow-legged Frog.

Signs of overgrazing include impacts to the streambanks such as increased slough-offs and cave-ins that collapse undercuts used as refuge (Kauffman et al. 1983). Overgrazing reduces riparian cover, increases erosion and sedimentation, which as described above can result in silt degradation of breeding, rearing, and invertebrate food-producing areas (Cordone and Kelley 1961, Behnke and Raleigh 1978, Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). Loss of streamside and instream vegetative cover and changes to channel morphology can increase water temperatures and velocities (Behnke and Raleigh 1978). Water quality can be affected by increased turbidity and nutrient input from excrement, and seasonal water quantity can be impacted through changes to channel morphology (Belsky et al. 1999). In addition, increased nutrients and temperatures can promote blooms of harmful cyanobacteria like *Microcystis aeruginosa*, which releases a toxin when it expires that can cause liver damage to amphibians as well as other animals including humans (Bobzien and DiDonato 2007, Zhang et al. 2013).

While some recent studies indicate livestock grazing continues to damage stream and riparian ecosystems, its impact on Foothill Yellow-legged Frogs in California is unknown (Belsky et al. 1999, Hayes et al. 2016). In Oregon, the species' presence was correlated with significantly less grazing than where they were absent according to Borisenko and Hayes's 1999 report (as cited in Olson and Davis 2009). However, Fellers (2005) reported that apparently some Coast Range foothill populations occupying streams draining east into the San Joaquin Valley were doing well at the time of publication despite being heavily grazed.

Urbanization and Road Effects

Habitat conversion and fragmentation combined with modified environmental disturbance regimes can substantially jeopardize biological diversity (Tracey et al. 2018). This threat is most severe in areas like California with Mediterranean-type ecosystems that are biodiversity hot spots, fire-prone, and heavily altered by human land use (Ibid.). From 1990 to 2010, the fastest-growing land use type in the conterminous U.S. was new housing construction, which rapidly expanded the wildland-urban interface (WUI) where houses and natural vegetation meet or intermix on the landscape (Radeloff et al. 2018).

Of several variables tested, proportion of urban land use within a 5 km (3.1 mi) radius of a site was associated with Foothill Yellow-legged Frog declines (Davidson et al. 2002). Lind (2005) also found significantly less urban development nearby and upwind of sites occupied by Foothill Yellow-legged Frogs, suggesting pollutant drift may be a contributing factor. Changes in wildfires may also contribute to the species' declines; 95% of California's fires are human-caused, and wildfire issues are greatest at the WUI (Syphard et al. 2009, Radeloff et al. 2018). Population density, intermix WUI (where wildland and development intermingle as opposed to an abrupt interface), and distance to WUI explained the most variability in fire frequency (Syphard et al. 2007). In addition to wildfires, habitat loss, and fragmentation, urbanization can impact adjacent ecosystems through non-native species introduction, native predator subsidization, and disease transmission (Bar-Massada et al. 2014).

Projections show growth in California's population to 51 million people by 2060 from approximately 40 million currently (PPIC 2019). This will increase urbanization, the WUI, and habitat fragmentation. The Department of Finance projects the Inland Empire, the San Joaquin Valley, and the Sacramento metropolitan area will be the fastest-growing regions of the state over the next several decades (Ibid.). This puts the greatest pressure in areas outside of the Foothill Yellow-legged Frog's range; however, because the environmental stressors associated with urbanization can span far beyond its physical footprint, they may still adversely affect the species.

Highways are frequently recognized as barriers to dispersal that fragment habitats and populations; however, single-lane roads can pose significant risks to wildlife as well (Cook et al. 2012, Brehme et al. 2018). Foothill Yellow-legged Frogs are at risk of being killed by vehicles when roads are located near their habitat (Cook et al. 2012, Brehme et al. 2018). Fifty-six juvenile Foothill Yellow-legged Frogs were found on a road adjacent to Sulphur Creek (Mendocino County), seven of which had been struck and killed (Cook et al. 2012). When fords (naturally shallow areas) are used as vehicle crossings, they can create sedimentation and poor water quality, and in some cases, the fords are gravel or cobble bars used by Foothill Yellow-legged Frogs for breeding that could result in direct mortality (K. Blanchard pers. comm. 2018, R. Bourque pers. comm. 2018). Construction of culverts under roads to keep vehicles out of the streambed can result in varying impacts. In some cases, they can impede dispersal and create deep scoured pools that support predatory fish and frogs, but when properly constructed, they can facilitate frog movement up and down the channel with reduced road mortality (Van Wagner 1996, GANDA 2008). In areas where non-native species are not a threat, but premature drying is, pools created by culverts can provide habitat in otherwise unsuitable areas (M. Grefsrud pers. comm. 2019). An evaluation of the impact of roads on 166 native California amphibians and reptiles through direct

mortality and barriers to movement concluded that Foothill Yellow-legged Frogs, at individual and population levels, were at moderate risk of road impacts in aquatic habitat but very low risk of impacts in terrestrial habitat (Brehme et al. 2018). For context, all chelonids (turtles and tortoises), 72% of snakes, 50% of anurans, 18% of lizards, and 17% of salamander species in California were ranked as having a high or very high risk of negative road impacts in the same evaluation (Ibid.).

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Poorly constructed roadways near rivers and streams can result in substantial erosion and sedimentation, leading to reduced amphibian densities (Welsh and Ollivier 1998). Proximity of roads to Foothill Yellow-legged Frog habitat contributes to petrochemical runoff and poses the threat of spills (Ashton et al. 1997). A diesel spill on Hayfork Creek (Trinity County) resulted in mass mortality of Foothill Yellow-legged Frog tadpoles and partial metamorphs (Bury 1972). Roads have also been implicated in the spread of disease and may have aided in the spread of Bd in California (Adams et al. 2017b).

Frogs use auditory and visual cues to defend territories and attract mates, and some studies reveal that realistic levels of traffic noise can impede transmission and reception of these signals (Bee and Swanson 2007). Some male frogs have been observed changing the frequency of their calls to increase the distance they can be heard over traffic noise, but if females have evolved to recognize lower pitched calls as signs of superior fitness, this potential trade-off between audibility and attractiveness could have implications for reproductive success (Parris et al. 2009). In a separate study, traffic noise caused a change in male vocal sac coloration and an increase in stress hormones, which changed sexual selection processes and suppressed immunity (Troïanowski et al. 2017). Because Foothill Yellow-legged Frogs mostly call underwater and are not known to use color displays, communication cues may not be adversely affected by traffic noise, but their stress response is unknown.

Timber Harvest

Because Foothill Yellow-legged Frogs tend to remain close to the water channel (i.e., within the riparian corridor) and current timber harvest practices minimize disturbance in riparian areas for the most part, adverse effects from timber harvest are expected to be relatively low (Hayes et al. 2016, CDFW 2018b). However, some activities have a potential to negatively impact Foothill Yellow-legged Frogs or their habitat, including direct mortality and increased sedimentation during construction and decommissioning of watercourse crossings and infiltration galleries, tree felling, log hauling, and entrainment by water intakes or desiccation of eggs and tadpoles through stranding from dewatering during drafting operations (CDFW 2018b,c). In addition to impacts previously described under the Sedimentation and Road Effects section, when silt runoff into streams is accompanied by organic materials, such as logging debris, impaired water quality can result, including reduced dissolved oxygen, which is important in embryonic and tadpole development (Cordone and Kelley 1961).

Because Foothill Yellow-legged Frogs are heliotherms (i.e, they bask in the sun to raise their body temperature) and sensitive to thermal extremes, some moderate timber harvest may benefit the species (Zweifel 1955, Fellers 2005). Ashton (2002) reported 85% of his Foothill Yellow-legged Frog observations occurred in second-growth forests (37-60 years post-harvest) as opposed to late-seral forests and postulated that the availability of some open canopy areas played a major part in this

disparity. Foothill Yellow-legged Frogs are typically absent in areas with closed canopy (Welsh and Hodgson 2011). Reduced canopy also raises stream temperatures, which could improve tadpole development and promote algal and invertebrate productivity in otherwise cold streams (Olson and Davis 2009; Catenazzi and Kupferberg 2013,2017).

Recreation

Several types of recreation can adversely impact Foothill Yellow-legged Frogs, and some are more severe and widespread than others. One of the main potential factors identified by herpetologists as contributing to disappearance of Foothill Yellow-legged Frogs in southern California was increased and intensified recreation in streams (Adams et al. 2017b). The greater number of people traveling into the backcountry may have facilitated the spread Bd to these areas, and while no evidence shows stress from disturbance or other environmental pressures increases susceptibility to Bd, the stress hormone corticosterone has been implicated in immunosuppression (Hayes et al. 2003, Adams et al. 2017b).

The amount of Foothill Yellow-legged Frog habitat disturbed by off-highway motor vehicles (OHV) throughout its range in California is unknown, but its impacts can be significant, particularly in areas with small isolated populations (Kupferberg et al. 2009c, Kupferberg and Furey 2015). An example is the Carnegie State Vehicular Recreation Area (CVSRA), located in the hills southwest of Tracy in the Corral Hollow Creek watershed (Alameda and San Joaquin counties). The above-described road effects apply: sedimentation, crushing along trail crossings, and potential noise effects (Ibid.). In addition, dust suppression activities employed by CSVRA use magnesium chloride ($MgCl_2$), which has the potential to harm developing embryos and tadpoles (Karraker et al. 2008, Hopkins et al. 2013, OHMVRC 2017). Based on museum records, Foothill Yellow-legged Frogs were apparently abundant in Corral Hollow Creek, but they are extremely rare now and are already extirpated or at risk of extirpation (Kupferberg et al. 2009c, Kupferberg and Furey 2015).

Motorized and non-motorized recreational boating can also impact Foothill Yellow-legged Frogs. The impacts of jet boat traffic were investigated in Oregon; in areas with frequent use and high wakes breaking on shore, Foothill Yellow-legged Frogs were absent (Borisenko and Hayes 1999 as cited in Olson and Davis 2009). This wake action had the potential to dislodge egg masses, strand tadpoles, disrupt adult basking behavior, and erode shorelines (Ibid.). Jet boat tours and races on the Klamath River (Del Norte and Humboldt counties) may have an impact on Foothill Yellow-legged Frog use of the mainstem (M. van Hattem pers. comm. 2019). In addition, using gravel bars as launch and haul out sites for boat trailers, kayaks, or river rafts can result in direct loss of egg masses and tadpoles or damage to breeding and rearing habitat and can disrupt post-metamorphic frog behavior (Ibid.). As described above, pulse flows released for whitewater boating in the late spring and summer can result in scouring and stranding of egg masses and tadpoles (Borisenko and Hayes 1999 as cited in Olson and Davis 2009, Kupferberg et al. 2009b). In addition, the velocities that resulted in stunted growth and increased vulnerability to predation in Foothill Yellow-legged Frog tadpoles were less than the increased velocities experienced in nearshore habitats during intentional release of recreational flows for whitewater boating, as well as hydropeaking for power generation (Kupferberg et al. 2011b).

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Hiking, horse-riding, camping, fishing, and swimming, particularly in sensitive breeding and rearing habitat can also adversely impact Foothill Yellow-legged Frog populations (Borisenko and Hayes 1999 in Olson and Davis 2009). Because Foothill Yellow-legged Frog breeding activity was being disturbed and egg masses were being trampled by people and dogs using Carson Falls (Marin County), the land manager established an educational program, including employing docents on weekends that remind people to stay on trails and tread lightly to try to reduce the loss of Foothill Yellow-legged Frog reproductive effort (Prado 2005). In addition, within his study site, Van Wagner (1996) reported that a property owner moved rocks that were being used as breeding habitat to create a swimming hole. The extent to which this is more than a small, local problem is unknown, but as the population of California increases, recreational pressures in Foothill Yellow-legged Frog habitat are likely to increase commensurately.

Drought

Drought is a common phenomenon in California and is characterized by lower than average precipitation. Lower precipitation in general results in less surface water, and water availability is critical for obligate stream-breeding species. Even in the absence of drought, a positive relationship exists between precipitation and latitude within the Foothill Yellow-legged Frog's range in California, and mean annual precipitation has a strong influence on Foothill Yellow-legged Frog presence at historically occupied sites (Davidson et al. 2002, Lind 2005). Figure 22 depicts the recent historical annual average precipitation across the state as well as during the most recent drought and how they differ. Southern California is normally drier than northern California, but the severity of the drought was even greater in the south.

Reduced precipitation can result in deleterious effects to Foothill Yellow-legged Frogs beyond the obvious premature drying of aquatic habitat. When stream flows recede during the summer and fall, sometimes the isolated pools that stay perennially wet are the only remaining habitat. This phenomenon concentrates aquatic species, resulting in several potentially significant adverse impacts. Stream flow volume was negatively correlated with Bd load during a recent chytridiomycosis outbreak in the Alameda Creek watershed (Adams et al. 2017a). The absence of high peak flows in winter coupled with wet years allowed bullfrogs to expand their distribution upstream, and the drought-induced low flows in the fall concentrated them with Foothill Yellow-legged Frogs in the remaining drying pools (Ibid.). This mass mortality event appeared to have been the result of a combination of drought, disease, and dam effects (Ibid.). This die-off occurred in a regulated reach that experiences heavy recreational use and presence of crayfish and bass (Ibid.). Despite these threats, the density of breeding females in this reach was greater in 2014 and 2015 than the in the unregulated reach upstream because the latter dried completely before tadpoles could metamorphose during the preceding drought years (S. Kupferberg, R. Peek, and A. Catenazzi pers. comm. 2015).

In addition to increasing the spread of pathogens, drought-induced stream drying can increase predation and competition by introduced fish and frogs in the pools they are forced to share (Moyle 1973, Hayes and Jennings 1988, Drost and Fellers 1996). This concentration in isolated pools can also result in increased native predation as well as facilitate spread of Bd. An aggregation of six adult Foothill

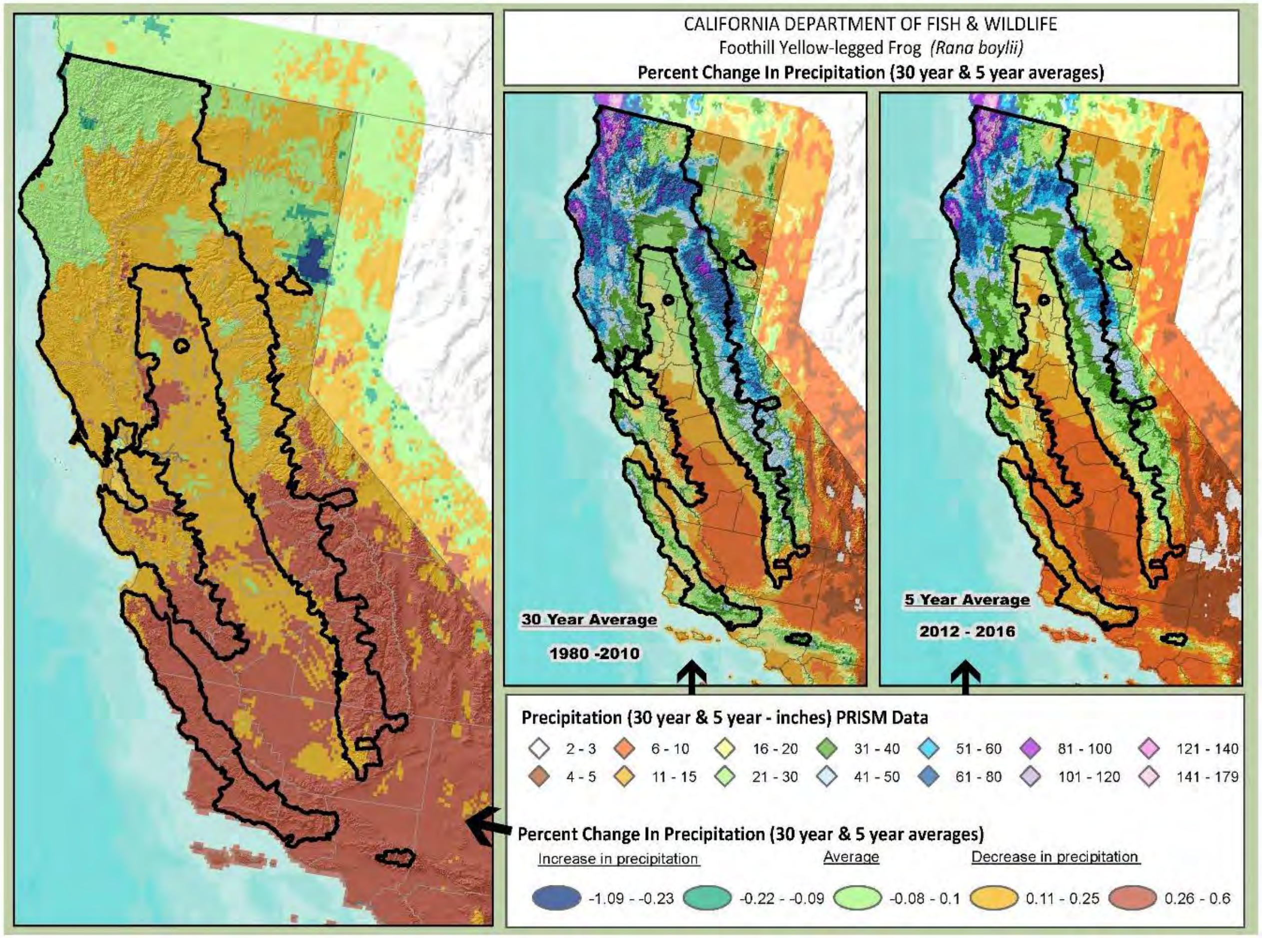


Figure 22. Change in precipitation from 30-year average and during the recent drought (PRISM)

Yellow-legged Frogs was observed perched on a rock above an isolated pool where a gartersnake was foraging on tadpoles during the summer; this close contact may reduce evaporative water loss when they are forced out of the water during high temperatures, but it can also increase disease transmission risk (Leidy et al. 2009.). Gonsolin (2010) also documented a late summer aggregation of juvenile Foothill Yellow-legged Frogs out of water during extremely high temperatures. In addition, drought-induced low flow, high water temperatures, and high densities of tadpoles were associated with outbreaks of malformation-inducing parasitic copepods (Kupferberg et al. 2009a).

Rapidly receding spring flows can result in stranding egg masses and tadpoles. However, this risk is likely less significant when it is drought-induced on an unregulated stream vs. a result of dam operations since Foothill Yellow-legged Frogs have evolved to initiate breeding earlier and shorten the breeding period in drought years (Kupferberg 1996a). If pools stay wet long enough to support metamorphosis, complete drying at the end of the season may benefit Foothill Yellow-legged Frogs if it eliminates introduced species like warm water fish and bullfrogs. Moyle (1973) noted that the only intermittent streams occupied by Foothill Yellow-legged Frogs in the Sierra Nevada foothills had no bullfrogs. At a long-term study site in upper Coyote Creek in 2015, Foothill Yellow-legged Frogs had persisted in reaches that had at least some summer water through the three preceding years of the most severe drought in over a millennium, albeit at much lower abundance than a decade before (Gonsolin 2010, Griffin and Anchokaitis 2014, J. Smith pers. comm. 2015). The population's abundance appeared to have never recovered from the 2007-2009 drought before the 2012-2016 drought began (J. Smith pers. comm. 2015). In 2016, after a relatively wet winter, Foothill Yellow-legged Frogs bred en-masse, and only a single adult bullfrog was detected, an unusually low number for that area (CDWR 2016, J. Smith pers. comm. 2016). It appeared the population may rebound; however, in 2018, it experienced lethal chytridiomycosis outbreak, and like the Alameda Creek die-off probably resulted from crowding during drought, presence of bullfrogs as Bd-reservoirs and predators and competitors, and the stress associated with the combination of the two (Kupferberg and Catenazzi 2019).

Drought effects can also exacerbate other environmental stressors. During the most recent severe drought, tree mortality increased dramatically from 2014 to 2017 and reached approximately 129 million dead trees (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are more prone to severe wildfires, and they lose their carbon sequestration function while also emitting methane, which is an extremely damaging greenhouse gas (CNRA 2016). Post-wildfire, storms can result in erosion of fine sediments from denuded hillsides into the stream channel (Florsheim et al. 2017). If the storms are short duration and low precipitation, as happens during droughts, their magnitude may not be sufficient to transport the material downstream, resulting in a longer temporal loss or degradation of stream habitat (Ibid.). Reduced rainfall may also infiltrate the debris leading to subsurface flows rather than the surface water Foothill Yellow-legged Frogs require (Ibid.). Extended droughts increase risk of the stream being uninhabitable or inadequate for breeding for multiple years, which would result in population-level impacts and possible extirpation (Ibid.).

Wildland Fire and Fire Management

Fire is an important element for shaping and maintaining the species composition and integrity of many California ecosystems (Syphard et al. 2007, SBFFP 2018). Prior to European settlement, an estimated 1.8 to 4.9 million ha (4.5-12 million ac) burned annually (4-11% of total area of the state), ignited both deliberately by Native Americans and through lightning strikes (Keeley 2005, SBFFP 2018). The impacts of wildland fires on Foothill Yellow-legged Frogs are poorly understood and likely vary significantly across the species' range with differences in climate, vegetation, soils, stream-order, slope, frequency, and severity (Olson and Davis 2009). Mortality from direct scorching is unlikely because Foothill Yellow-legged Frogs are highly aquatic, and most wildfires occur during the dry period of the year when the frogs are most likely to be in or near the water (Pilliod et al. 2003, Bourque 2008). Field observations support this presumption; sightings of post-metamorphic Foothill Yellow-legged Frogs immediately after fires in the northern Sierra Nevada and North Coast indicate they are not very vulnerable to the direct effects of fire (S. Kupferberg and R. Peek pers. comm. 2018). Similarly, Foothill Yellow-legged Frogs were observed two months, and again one year, after a low- to moderate-intensity fire burned an area in the southern Sierra Nevada in 2002, and the populations were extant and breeding as recently as 2017 (Lind et al. 2003b, CNDDB 2019). While water may provide a refuge during the fire, it is also possible for temperatures during a fire, or afterward due to increased solar exposure, to near or exceed a threshold resulting lethal or sublethal harm; this would likely impact embryos and tadpoles with limited dispersal abilities (Pilliod et al. 2003).

Intense fires remove overstory canopy, which provides insulation from extreme heat and cold, and woody debris that increases habitat heterogeneity (Pilliod et al. 2003, Olson and Davis 2009). If this happens frequently enough, it can permanently change the landscape. For example, frequent high-severity burning of crown fire-adapted ecosystems can prevent forest regeneration since seeds require sufficient time between fires to mature, and repeated fires can deplete the seed bank (Stephens et al. 2014). Smoke and ash change water chemistry through increased nutrient and heavy metal inputs that can reach concentrations harmful to aquatic species during the fire and for days, weeks, or years after (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Erosion rates on granitic soils, which make up a large portion of the Foothill Yellow-legged Frog's range, can be over 60 times greater in burned vs. unburned areas and can increase sedimentation for over 10 years (Megahan et al. 1995, Hayes et al. 2016). Post-fire nutrient inputs into streams could benefit Foothill Yellow-legged Frogs through increased productivity and more rapid growth and development (Pilliod et al. 2003). While the loss of leaf litter that accompanies fire alters the food web, insects are expected to recolonize rapidly, and the lack of cover could increase their vulnerability to predation by Foothill Yellow-legged Frogs (Ibid.).

Low-intensity fires likely have no adverse effect on Foothill Yellow-legged Frogs (Olson and Davis 2009). If they occur in areas with dense canopy, wildfires can improve habitat quality for Foothill Yellow-legged Frogs by reducing riparian cover, providing areas to bask, and increasing habitat heterogeneity, which is likely to outweigh any adverse effects from some fire-induced mortality (Russell et al. 1999, Olson and Davis 2009). In a preliminary analysis of threats to Foothill Yellow-legged Frogs in Oregon, proximity to stand-replacing fires was not associated with absence (Olson and Davis 2009).

Euro-American colonization of California significantly altered the pattern of periodic fires with which California's native flora and fauna evolved through fire exclusion, land use practices, and development (OEHHA 2018). Fire suppression can lead to canopy closure, which reduces habitat quality by limiting thermoregulatory opportunities (Olson and Davis 2009). In addition, fire suppression and its subsequent increase in fuel loads combined with expanding urbanization and rising temperatures have resulted in a greater likelihood of catastrophic stand-replacing fires that can significantly alter riparian systems for decades (Pilliod et al. 2003). Firebreaks, in which vegetation is cleared from a swath of land, can result in similar impacts to roads and road construction (Ibid.). Fire suppression can also include bulldozing within streams to create temporary reservoirs for pumping water, which can cause more damage than the fire itself to Foothill Yellow-legged Frogs in some cases (S. Kupferberg and R. Peek pers. comm. 2018). In addition, fire suppression practices can involve applying hundreds of tons of ammonia-based fire retardants and surfactant-based fire suppressant foams from air tankers and fire engines (Pilliod et al. 2003). Some of these chemicals are highly toxic to some anurans (Little and Calfee 2000).

Fire suppression has evolved into fire management with a greater understanding of its importance in ecosystem health (Keeley and Syphard 2016). Several strategies are employed including prescribed burns, mechanical fuels reduction, and allowing some fires to burn instead of necessarily extinguishing them (Pilliod et al. 2003). Like wildfires themselves, fire management strategies have the potential to benefit or harm Foothill Yellow-legged Frogs. Prescribed fires and mechanical fuels removal lessen the likelihood of catastrophic wildfires, but they can also result in loss of riparian vegetation, excessive sedimentation, and increased water temperatures (Ibid.). Salvage logging after a fire may result in similar impacts to timber harvest but with higher rates of erosion and sedimentation (Ibid.). A balanced approach to wildland fires is likely to have the greatest beneficial impact on species and ecosystem health (Stephens et al. 2012).

Floods and Landslides

As previously described, Foothill Yellow-legged Frog persistence is highly sensitive to early life stage mortality (Kupferberg et al. 2009c). While aseasonal dam releases are a major source of egg mass and tadpole scouring, storm-driven floods are also capable of it (Ashton et al. 1997). Van Wagner (1996) concluded that the high discharge associated with heavy rainfall could account for a significant source of mortality in post-metamorphic Foothill Yellow-legged Frogs as well as eggs and tadpoles; he observed two adult females and several juveniles swept downstream with fatal injuries post-flooding. Severe flooding, specifically two 500-year flood events in early 1969 in Evey Canyon (Los Angeles County), resulted in massive riparian habitat destruction (Sweet 1983). Prior to the floods, Foothill Yellow-legged Frogs were widespread and common, but only four subsequent sightings were documented between 1970 and 1974 and none since (Sweet 1983, Adams 2017b). Sweet (1983) speculates that because Foothill Yellow-legged Frogs overwinter in the streambed in that area, the floods may have reduced the population's abundance below an extinction threshold. Four other herpetologists interviewed about Foothill Yellow-legged Frog extirpations in southern California listed severe flooding as a likely cause (Adams et al. 2017b).

As mentioned above, landslides are a frequent consequence of post-fire rainstorms and can result in lasting impacts to stream morphology, water quality, and Foothill Yellow-legged Frog populations. On the other hand, Olson and Davis (2009) suggest that periodic landslides can have beneficial effects by transporting woody debris into the stream that can increase habitat complexity and by replacing sediments that are typically washed downstream over time. Whether a landslide is detrimental or beneficial is likely heavily influenced by amount of precipitation and the underlying system. As previously described, too little precipitation could lead to prolonged loss of habitat through failure to transport material downstream, and too much precipitation can result in large-scale habitat destruction and direct mortality.

Commented [RAP18]: I think this is an important point…the frequency at which landslides occur in a region or reach is really crucial. If we have a lot of fire in the future, and the odds of having landslides in burned areas goes up, repeated slides in unstable areas could definitely have a significantly negative impact as compared to a large slide that happens infrequently.

Climate Change

Global climate change threatens biodiversity and may lead to increased frequency and severity of drought, wildfires, flooding, and landslides (Williams et al. 2008, Keely and Syphard 2016). Data show a consistent trend of warming temperatures in California and globally; 2014 was the warmest year on record, followed by 2015, 2017, and 2016 (OEHHA 2018). Climate model projections for annual temperature in California in the 21st century range from 1.5 to 4.5°C (2.7-8.1°F) greater than the 1961-1990 mean (Cayan et al. 2008). Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation, and increasingly dry conditions in California resulting from increased evaporative water loss primarily due to rising temperatures (Cayan et al. 2005, Williams et al. 2015, OEHHA 2018). Precipitation variability and proportion of dry years were negatively associated with Foothill Yellow-legged Frog presence in a range-wide analysis (Lind 2005). In addition, low precipitation intensified the adverse effects of dams on the species (Ibid.).

California recently experienced the longest drought since the U.S. Drought Monitor began reporting in 2000 (NIDIS 2019). Until March 5, 2019, California experienced drought effects in at least a portion of the state for 376 consecutive weeks; the most intense period occurred during the week of October 28, 2014 when D4 (the most severe drought category) affected 58.4% of California's land area (Figure 23; NIDIS 2019). A recent modeling effort using data on historical droughts, including the Medieval megadrought between 1100 and 1300 CE, indicates the mean state of drought from 2050 to 2099 in California will likely exceed the Medieval-era drought, under both high and moderate greenhouse gas emissions models (Cook et al. 2015). The probability of a multidecadal (35 yr) drought occurring during the late 21st century is greater than 80% in all models used by Cook et al. (2015). If correct, this would represent a climatic shift that not only falls outside of contemporary variability in aridity but would also be unprecedented in the past millennium (Ibid.).

As a result of increasing temperatures, a decreasing proportion of precipitation falls as snow, resulting in more runoff from rainfall during the winter and a shallower snowpack that melts more rapidly (Stewart 2009). A combination of reduced seasonal snow accumulation and earlier streamflow timing significantly reduces surface water storage capacity and increases the risk for winter and spring floods, which may require additional and taller dams and result in alterations to hydroelectric power generation flow regimes (Cayan et al. 2005, Knowles et al. 2006, Stewart 2009). The reduction in snowmelt volume

is expected to impact the northern Sierra (Feather, Yuba, and American River watersheds) to a greater extent than the southern portion (Young et al. 2009). The earlier shift in peak snowmelt timing is predicted to exceed four to six weeks across the entire Sierra Nevada depending on the amount of warming that occurs this century (Ibid.). In addition, the snow water equivalent is predicted to significantly decline by 2070-2099 over the 1961-1990 average in the Trinity, Sacramento, and San Joaquin drainages from -32% to -79%, and effectively no snow is expected to fall below 1000 m (3280 ft) in the high emissions/sensitive model (Cayan et al. 2008).

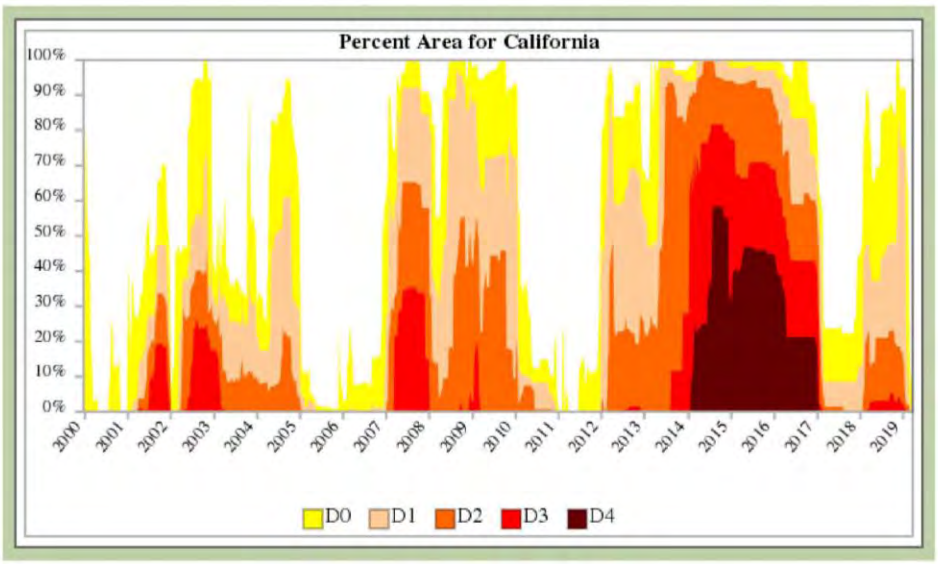


Figure 23. Palmer Hydrological Drought Indices 2000-present (NIDIS)

The earlier shift of snowmelt and lower water content will result in lower summer flows, which will intensify the competition for water among residential, agricultural, industrial, and environmental needs (Field et al. 1999, Cook et al. 2015). In unregulated systems, as long as water is present through late summer, an earlier hydrograph recession that triggers Foothill Yellow-legged Frog breeding could result in a longer time to grow larger prior to metamorphosis, which improves probability of survival (Yarnell et al. 2010, Kupferberg 2011b). However, if duration from peak to base flow shortens, it can result in increased sedimentation and reduced habitat complexity in addition to stranding (Yarnell et al. 2010).

Fire frequency relates to temperature, fuel loads, and fuel moisture (CCSP 2008). Therefore, increasing periods of drought combined with extreme heat and low humidity that stress or kill trees and other vegetation create ideal conditions for wildland fires (Ibid). Not surprisingly, the area burned by wildland fires over the western U.S. increased since 1950 but rose rapidly in the mid-1980s (Westerling et al. 2006, OEHHA 2018). As temperatures warmed and snow melted earlier, large-wildfire frequency and duration increased, and wildfire seasons lengthened (Westerling et al. 2006, OEHHA 2018).

In California, latitude inversely correlates with temperature and annual area burned, but the climate-fire relationship is substantially different across the state, and future wildfire regimes are difficult to predict (Keeley and Syphard 2016). For example, the relationship between spring and summer temperature and area burned in the Sierra Nevada is highly significant but not in southern California (Ibid.). Climate has a greater influence on fire regimes in mesic than arid environments, and the most influential climatological factor (e.g., precipitation, temperature, season, or their interactions) shifts over time (Ibid.). Nine of the 10 largest fires in California since 1932 have occurred in the past 20 years, 4 within the past 2 years (Figure 24; CAL FIRE 2019). However, it is possible this trend will not continue; climate- and wildfire-induced changes in vegetation could reduce wildfire severity in the future (Parks et al. 2016).

Wildfires themselves can accelerate the effects of climate change. Wildfires emit short-lived climate pollutants like black carbon (soot) and methane that are tens to thousands of times greater than carbon dioxide (the main focus of greenhouse gas reduction) in terms of warming effect and are responsible for 40% or more of global warming to date (CNRA 2016). Healthy forests can sequester large amounts of carbon from the atmosphere, but recently carbon emissions from wildfires have exceeded their uptake by vegetation in California (Ackerly et al. 2018).

With increased variability and changes in precipitation type, magnitude, and timing comes more variable and extreme stream flows (Mallakpour et al. 2018). Models for stream flow in California project higher high flows, lower low flows, wetter rainy seasons, and drier dry seasons (Ibid.). The projected water cycle extremes are related to strengthening El Niño and La Niña events, and both severe flooding and intense drought are predicted to increase by at least 50% by the end of the century (Yoon et al. 2015). These changes increase the likelihood of Foothill Yellow-legged Frog egg mass and tadpole scouring and stranding, even in unregulated rivers.

A species' vulnerability to climate change is a function of its sensitivity to climate change effects, its exposure to them, and its ability to adapt its behaviors to survive with them (Dawson et al. 2011). Myriad examples exist of species shifting their geographical distribution toward the poles and to higher elevations and changing their growth and reproduction with increases in temperature over time (Parmesan and Yohe 2003). However, in many places, fragmentation of suitable habitat by anthropogenic barriers (e.g., urbanization, agriculture, and reservoirs) limits a species' ability to shift its range (Pounds et al. 2007). The proportion of sites historically occupied by Foothill Yellow-legged Frogs that are now extirpated increases significantly on a north-to-south latitudinal gradient and at drier sites within California, suggesting climate change may contribute to the spatial pattern of the species' declines (Davidson et al. 2002).

An analysis of the climate change sensitivity of 195 species of plants and animals in northwestern North America revealed that, as a group, amphibians and reptiles were estimated to be the most sensitive (Case et al. 2015). Nevertheless, examples exist of amphibians adjusting their breeding behaviors (e.g., calling and migrating to breeding sites) to occur earlier in the year as global warming increases (Beebee 1995, Gibbs and Breisch 2001). Because of the rapid change in temperature, Beebee (1995) posits these are examples of behavioral and physiological plasticity rather than natural selection. However, for

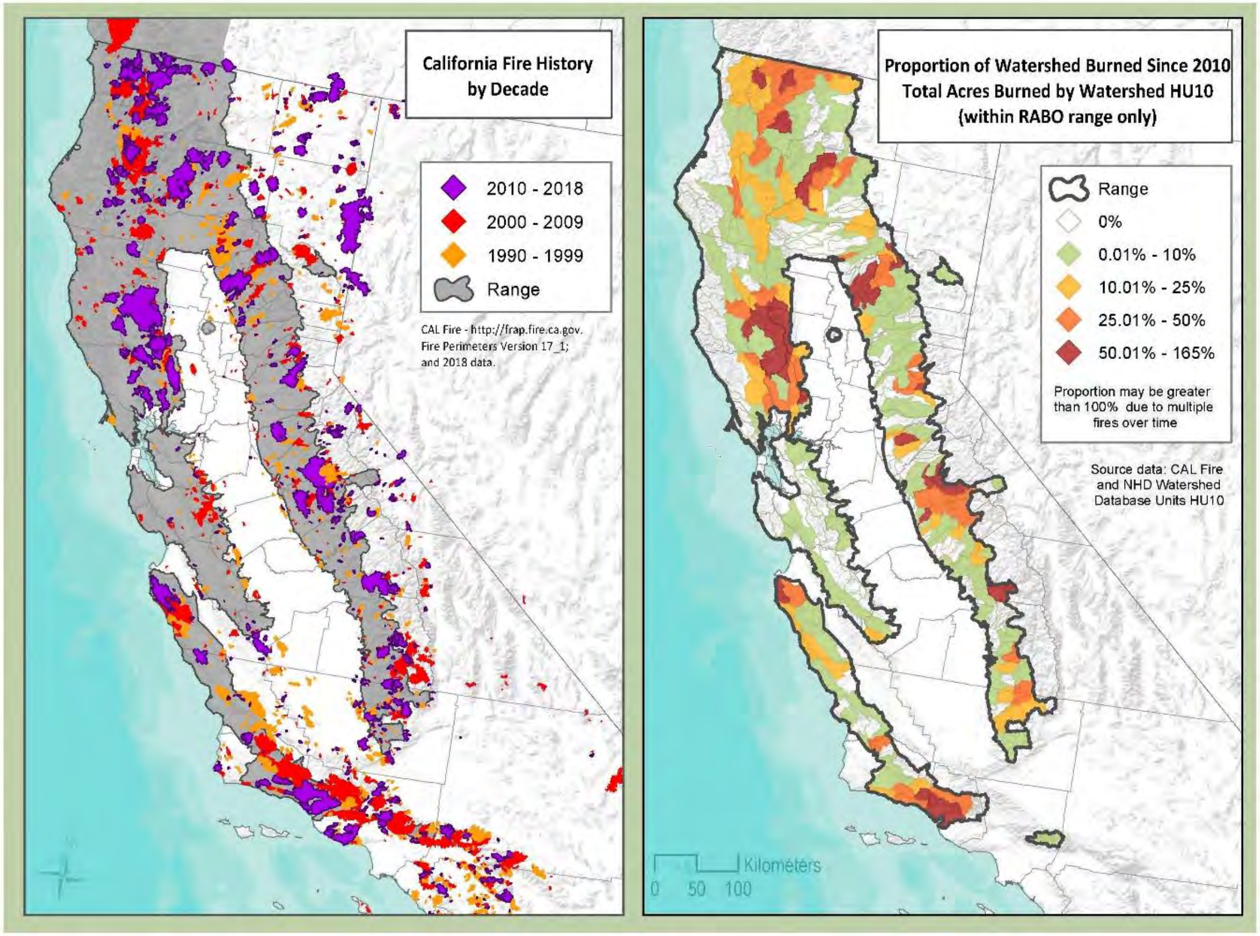


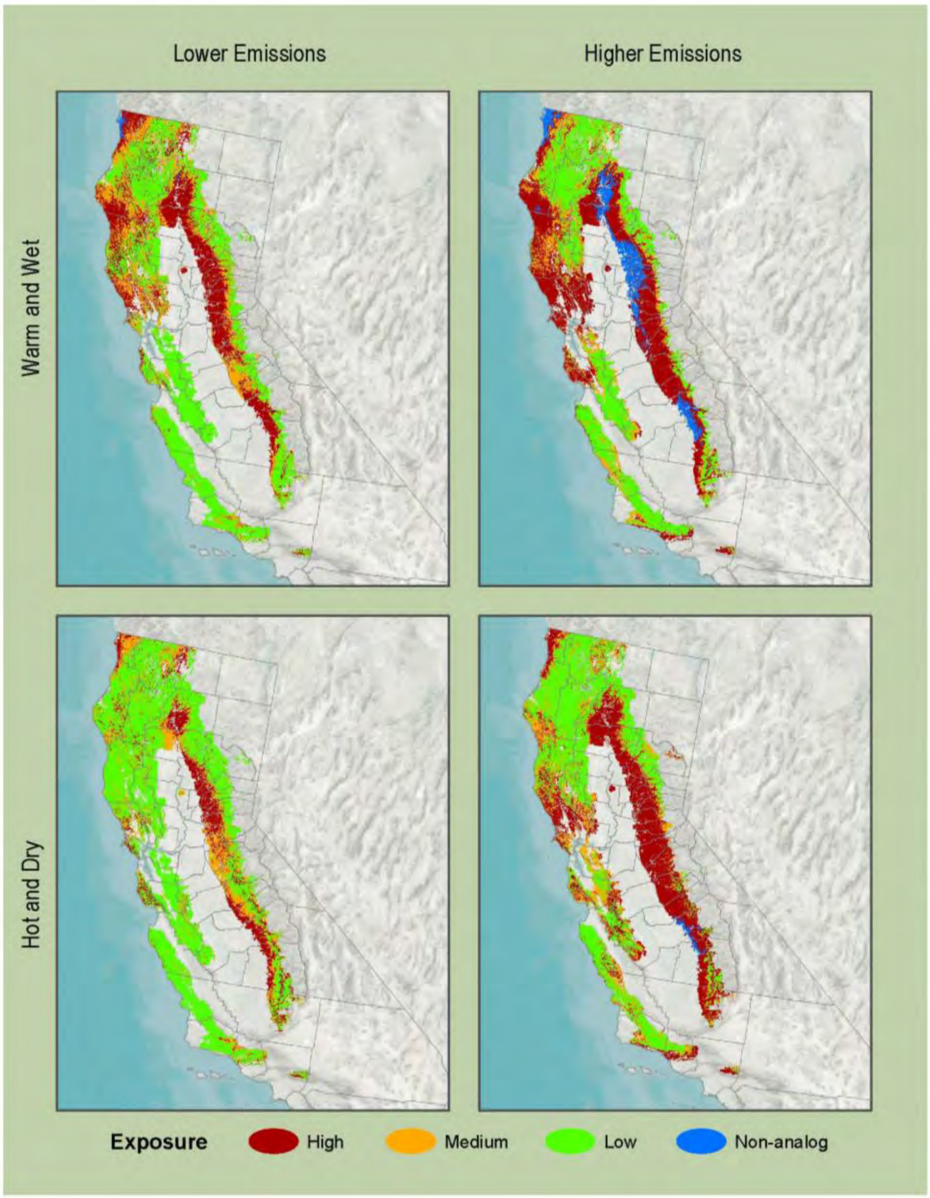
Figure 24. Fire history (1990-2018) and proportion of watershed burned (2010-2018) in California (CAL FIRE, NHD)

species with short generation times or in areas less affected by climate change, populations may be able to undergo evolutionary adaptation to the changing local environmental conditions (Hoffman and Sgrò 2011).

As previously described in the Seasonal Activity and Movements section, Foothill Yellow-legged Frog breeding is closely tied to water temperature, flow, and stage, and the species already adjusts its timing of oviposition by as much as a month or more in the same location during different water years, so the species may have enough inherent flexibility to reduce their vulnerability. The species appears fairly resilient to drought, fire, and flooding, at least in some circumstances. For example, after the 2012-2016 drought, the Loma Fire in late 2016, and severe winter flooding and landslides in 2016 and 2017, Foothill Yellow-legged Frog adults and metamorphs, as well as aquatic insects and rainbow trout, were abundant throughout Upper Llagas Creek in fall of 2017, and the substrate consisted of generally clean gravels and cobbles with only a slight silt coating in some pools (J. Smith pers. comm. 2017). The frogs and fish likely took refuge in a spring-fed pool, and the heavy rains scoured the fine sediments that eroded downstream (Ibid.). These refugia from the effects of climate change reduce the species' exposure, thereby reducing their vulnerability (Case et al. 2015).

Climate change models that evaluate the Foothill Yellow-legged Frog's susceptibility from a species and habitat perspective yield mixed results. An investigation into the possible effects of climate on California's native amphibians and reptiles used ecological niche models, future climate scenarios, and general circulation models to predict species-specific climatic suitability in 2050 (Wright et al. 2013). The results suggested approximately 90-100% of localities currently occupied by Foothill Yellow-legged Frogs are expected to remain climatically suitable in that time, and the proportion of currently suitable localities predicted to change ranges from -20% to 20% (Ibid.). However, a second study using a subset of these models found that 66.4% of currently occupied cells will experience reduced environmental suitability in 2050 (Warren et al. 2014). This analysis included 90 species of native California mammals, birds, reptiles, and amphibians. For context, over half of the taxa were predicted to experience > 80% reductions, a consistent pattern reflected across taxonomic groups (Ibid.).

A third analysis investigated the long-term risk of climate change by modeling the relative environmental stress a vegetative community would undergo in 2099 given different climate and greenhouse gas emission scenarios (Thorne et al. 2016). This model does not incorporate any Foothill Yellow-legged Frog-specific data; it strictly projects climatic stress levels vegetative communities will experience within the species' range boundaries (Ibid.). Unsurprisingly, higher emissions scenarios resulted in a greater proportion of habitat undergoing climatic stress (Figure 25). Perhaps counterintuitively, the warm and wet scenario resulted in a greater amount of stress than the hot and dry scenario. When high emissions and warm and wet changes are combined, a much greater proportion of the vegetation communities will experience "non-analog" conditions, those outside of the range of conditions currently known in California (Ibid.).



Source - model extracts from -Thorne, J.H. et al. (2016) A climate change vulnerability assessment of California's terrestrial vegetation. CDFW.

Figure 25. Vegetative community exposure to climate change in 2099 based on Thorne et al. (2016).

Habitat Restoration and Species Surveys

Potential conflicts between managing riverine habitat below dams for both cold-water adapted salmonids and Foothill Yellow-legged Frogs was discussed previously. In addition to problems with temperatures and pulse flows, some stream restoration projects aimed at physically creating or improving salmonid habitat can also adversely affect the species. For example, boulder deflectors were placed in Hurdygurdy Creek (Del Norte County) to create juvenile steelhead rearing habitat; deflectors change broad, shallow, low-velocity reaches into narrower, deeper, faster reaches preferred by the fish (Fuller and Lind 1992). Foothill Yellow-legged Frogs were documented using the restoration reach as breeding habitat annually prior to placement of the boulders, but no breeding was detected in the following three years, suggesting this project eliminated the conditions the frogs require (Ibid.). In addition, a fish ladder to facilitate salmonid migration above the Alameda Creek Diversion Dam was recently constructed on a Foothill Yellow-legged Frog lek site, and the frogs may become trapped in the ladder (M. Grefsrud pers. comm. 2019). Use of rotenone to eradicate non-native fish as part of a habitat restoration project is rare, but if it is applied in streams occupied by Foothill Yellow-legged Frogs, it can kill tadpoles but is unlikely to impact post-metamorphic frogs (Fontenot et al. 1994). Metamorphosing tadpoles may be able to stay close enough to the surface to breathe air and survive but may display lethargy and experience increased susceptibility to predation (Ibid.).

Commonly when riparian vegetation is removed, regulatory agencies require a greater amount to be planted as mitigation to offset the temporal loss of habitat. This practice can have adverse impacts on Foothill Yellow-legged Frogs by reducing habitat suitability. Foothill Yellow-legged Frogs have been observed moving into areas where trees were recently removed, and they are known to avoid heavily shaded areas (Welsh and Hodgson 2011, M. Grefsrud pers. comm. 2019).

Biologists conducting surveys in Foothill Yellow-legged Frog habitat can trample egg masses or larvae if they are not careful. One method for sampling fish is electroshocking, which runs a current through the water that stuns the fish temporarily allowing them to be captured. Post-metamorphic frogs are unlikely to be killed by electroshocking; however, at high frequencies (60 Hz), they may experience some difficulty with muscle coordination for a few days (Allen and Riley 2012). This could increase their risk of predation. At 30 Hz, there were no differences between frogs that were shocked and controls (Ibid.). Tadpoles are more similar to fish in tail muscle and spinal structure and are at higher risk of injuries; however, researchers who reported observing stunned tadpoles noted they appeared to recover completely within several seconds (Ibid.). Adverse effects to Foothill Yellow-legged Frogs from electrofishing may only happen at frequencies higher than those typically used for fish sampling (Ibid.)

Small Population Sizes

Small populations are at greater risk of extirpation, primarily through the disproportionately greater impact of demographic, environmental, and genetic stochasticity on them compared to large populations, so any of the threats previously discussed will likely have an even greater adverse impact on small populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). This risk of extinction from genetic stochasticity is amplified when connectivity between the small populations, and thus gene flow,

is impeded (Fahrig and Merriam 1985, Taylor et al. 1993, Lande and Shannon 1996, Palstra and Ruzzante 2008). Genetic diversity provides capacity to evolve in response to environmental changes, and the "rescue effect" of gene flow is important in minimizing probability of local extinction (Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). However, the rescue effect is diminished in conditions of high local environmental stochasticity of recruitment or survival (Eriksson et al. 2014). In addition, populations living near their physiological limits and lacking adaptive capacity may not be able to evolve in response to rapid changes (Hoffmann and Sgrò 2011). Furthermore, while pathogens or parasites rarely result in host extinction, they can increase its likelihood in small populations by driving the host populations below a critically low threshold beneath which demographic stochasticity can lead to extinction, even if they possess the requisite genetic diversity to adapt to a changed environment (Gomulkiewicz and Holt 1995, Adams et al. 2017b).

A Foothill Yellow-legged Frog PVA revealed that, even with no dam effects considered (e.g., slower growth and increased egg and tadpole mortality), populations with the starting average density of adult females in regulated rivers (4.6/km [2.9/mi]) were four times more likely to go extinct within 30 years than those with the starting average density of adult females from unregulated rivers (32/km [120/mi]) (Kupferberg et al. 2009c). When the density of females in sparse populations was used (2.1/km [1.3/mi], the 30-year risk of extinction increased 13-fold (Ibid.). With dam effects, a number of the risk factors above contribute to the additional probability of local extinction such as living near their lower thermal tolerance and reduced recruitment and survival from scouring and stranding flows, poor food quality, and increased predation and competition (Kupferberg 1997a; Hoffmann and Sgrò 2011; Kupferberg et al. 2011a,b; Kupferberg et al. 2012; Eriksson et al. 2014). These factors act synergistically, contributing in part to the small size, high divergence, and low genetic diversity exhibited by many Foothill Yellow-legged Frog populations located in highly regulated watersheds (Kupferberg et al. 2012, Peek 2018).

EXISTING MANAGEMENT

Land Ownership within the California Range

Using the Department's Foothill Yellow-legged Frog range boundary and the California Protected Areas Database (CPAD), a GIS dataset of lands that are owned in fee title and protected for open space purposes by over 1,000 public agencies or non-profit organizations, the total area of the species' range in California comprises 13,620,447 ha (33,656,857 ac) (CPAD 2019, CWHR 2019). Approximately 37% is owned by federal agencies, 80% of which (4,071,178 ha [10,060,100 ac]) is managed by the Forest Service (Figure 26). Department of Fish and Wildlife-managed lands, State Parks, and other State agency-managed lands constitute around 2.6% of the range. The remainder of the range includes < 1% Tribal lands, 2.3% other conserved lands (e.g., local and regional parks), and 57% private and government-managed lands that are not protected for open space purposes. It is important to note that even if included in the CPAD, a property's management does not necessarily benefit Foothill Yellow-legged Frogs, but in some cases changes in management to conserve the species may be easier to undertake than on private lands or public lands not classified as conserved.

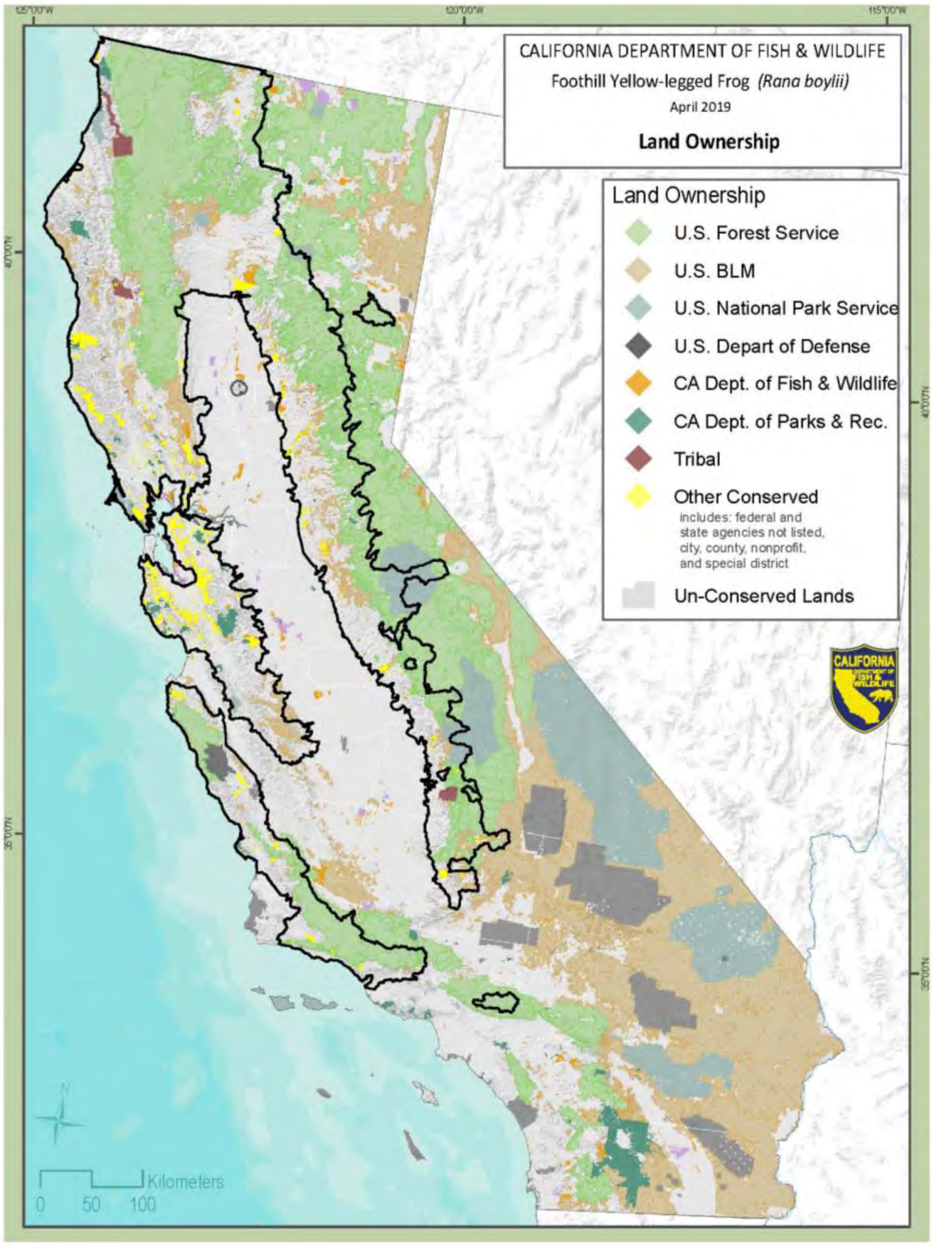


Figure 26. Conserved, Tribal, and other lands (BLM, CMD, CPAD, CWHR, DOD)

Statewide Laws

The laws and regulations governing land management within the Foothill Yellow-legged Frog's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California that may provide some level of protection for Foothill Yellow-legged Frogs and their habitat. The following is not an exhaustive list.

National Environmental Policy Act and California Environmental Quality Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. As a BLM and Forest Service Sensitive Species, impacts to Foothill Yellow-legged Legged Frogs are considered during NEPA analysis; however, the law has no requirement to minimize or mitigate adverse effects.

The California Environmental Quality Act (CEQA) is similar to NEPA; it requires state and local agencies to identify, analyze, and consider alternatives, and to publicly disclose environmental impacts from projects over which they have discretionary authority (Pub. Resources Code § 21000 et seq.). CEQA differs substantially from NEPA in requiring mitigation for significant adverse effects to a less than significant level unless overriding considerations are documented. CEQA requires an agency find projects may have a significant effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380.). CEQA establishes a duty for public agencies to avoid or minimize such significant effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to Foothill Yellow-legged Frogs, as an SSC, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA. However, a lead agency is not required to make a mandatory finding of significance conclusion unless it determines on a project-specific basis that the species meets the CEQA criteria for rare, threatened, or endangered.

Clean Water Act and Porter-Cologne Water Quality Control Act

The Clean Water Act originated in 1948 as the Federal Water Pollution Control Act of 1948. It was heavily amended in 1972 and became known as the Clean Water Act (CWA). The purpose of the CWA was to establish regulations for the discharge of pollutants into waters of the United States and establish quality standards for surface waters. Section 404 of the CWA forbids the discharge of dredged or fill material into waters and wetlands without a permit from the ACOE. The CWA also requires an alternatives analysis, and the ACOE is directed to issue their permit for the least environmentally damaging practicable alternative. The definition of waters of the United States has changed substantially over time based on Supreme Court decisions and agency rule changes.

The Porter-Cologne Water Quality Act was established by the State in 1969 and is similar to the CWA in that it establishes water quality standards and regulates discharge of pollutants into state waters, but it

also administers water rights which regulate water diversions and extractions. The SWRCB and nine Regional Water Boards share responsibility for implementation and enforcement of Porter-Cologne as well as the CWA's National Pollutant Discharge Elimination System permitting.

Federal and California Wild and Scenic Rivers Acts

In 1968, the U.S. Congress passed the federal Wild and Scenic Rivers Act (WSRA) (16 U.S.C. § 1271, et seq.) which created the National Wild and Scenic River System. The WSRA requires the federal government to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The WSRA prohibits the federal government from building, licensing, funding or otherwise aiding in the building of dams or other project works on rivers or segments of designated rivers. The WSRA does not give the federal government control of private property including development along protected rivers.

California's Wild and Scenic Rivers Act was enacted in 1972 so rivers that "possess extraordinary scenic, recreational, fishery, or wildlife values shall be preserved in their free-flowing state, together with their immediate environments, for the benefit and enjoyment of the people of the state." (Pub. Res. Code, § 5093.50). Designated waterways are codified in Public Resources Code sections 5093.50-5093.70. In 1981, most of California's designated Wild and Scenic Rivers were adopted into the federal system. Currently in California, 3,218 km (1,999.6 mi) of 23 rivers are protected by the WSRA, most of which are located in the northwest. Foothill Yellow-legged Frogs have been observed in 11 of the 17 designated rivers within their range (CNDDB 2019).

Lake and Streambed Alteration Agreements

Fish and Game Code Section 1602 requires entities to notify the Department of activities that "divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake, or deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake." If the activity may substantially adversely affect an existing fish and wildlife resource, the Department may enter into a lake or streambed alteration agreement with the entity that includes reasonable measures necessary to protect the fish or wildlife resource (Fish & G. Code, §1602, subd. (a)(4)(B)). A lake or stream alteration agreement does not authorize take of species listed as candidates, threatened, or endangered under CESA (see Protection Afforded by Listing for CESA compliance requirements).

Medicinal and Adult-Use Cannabis Regulation and Safety Act

The commercial cannabis cultivation industry is unique in that any entity applying for an annual cannabis cultivation license from California Department of Food and Agriculture (CDFA) must include "a copy of any final lake or streambed alteration agreement…or written verification from the California Department of Fish and Wildlife that a lake or streambed alteration agreement is not required" with their license application (Cal. Code Regs., tit. 3, § 8102, subd. (v)). The SWRCB also enforces the laws related to waste discharge and water diversions associated with cannabis cultivation (Cal. Code Regs., tit. 3, § 8102, subd. (p)).

Forest Practice Act

The Forest Practice Act was originally enacted in 1973 to ensure that logging in California is undertaken in a manner that will also preserve and protect the State's fish, wildlife, forests, and streams. This law and the regulations adopted by the California Board of Forestry and Fire Protection (BOF) pursuant to it are collectively referred to as the Forest Practice Rules. The Forest Practice Rules implement the provisions of the Forest Practice Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. The California Department of Forestry and Fire Protection (CAL FIRE) enforces these laws and regulations governing logging on private land.

Federal Power Act

The Federal Power Act and its major amendments are implemented and enforced by FERC and require licenses for dams operated to generate hydroelectric power. One of the major amendments required that these licenses "shall include conditions for the protection, mitigation and enhancement of fish and wildlife including related spawning grounds and habitat" (ECPA 1986). Hydropower licenses granted by FERC are usually valid for 30-50 years. If a licensee wants to renew their license, it must file a Notice of Intent and a pre-application document five years before the license expires to provide time for public scoping, any potentially new studies necessary to analyze project impacts and alternatives, and preparation of environmental documents. The applicant must officially apply for the new license at least two years before the current license expires.

As a federal agency, FERC must comply with federal environmental laws prior to issuing a new license or relicensing an existing hydropower project, which includes NEPA and ESA. As a result of environmental compliance or settlement agreements formed during the relicensing process, some operations have been modified and habitat restored to protect fish and wildlife. For example, the Lewiston Dam relicensing resulted in establishment of the Trinity River Restoration Program, which takes an ecosystem-approach to studying dam effects and protecting and restoring fish and wildlife populations downstream of the dam (Snover and Adams 2016). Similarly, relicensing of the Rock Creek-Cresta Project on the North Fork Feather River resulted in establishment of a multi-stakeholder Ecological Resources Committee (ERC). As a result of the ERC's studies and recommendations, pulse flows for whitewater boating were suspended for several years following declines of Foothill Yellow-legged Frogs, and the ERC is currently working toward augmenting the population in an attempt to increase abundance to a viable level.

Administrative and Regional Plans

Forest Plans

NORTHWEST FOREST PLAN

In 1994, BLM and the Forest Service adopted the Northwest Forest Plan to guide the management of over 97,000 km^2 (37,500 mi^2) of federal lands in portions of northwestern California, Oregon, and Washington. The Northwest Forest Plan created an extensive network of forest reserves including

Riparian Reserves. Riparian Reserves apply to all land designations to protect riparian dependent resources. With the exception of silvicultural activities consistent with Aquatic Conservation Strategy objectives, timber harvest is not permitted within Riparian Reserves, which can vary in width from 30 to 91 m (100-300 ft) on either side of streams, depending on the classification of the stream or waterbody (USFS and BLM 1994). Fuel treatment and fire suppression strategies and practices implemented within these areas are designed to minimize disturbance.

Sierra Nevada Forest Plan

Land and Resource Management Plans for forests in the Sierra Nevada were changed in 2001 by the Sierra Nevada Forest Plan Amendment and subsequently adjusted via a supplemental Environmental Impact Statement and Record of Decision in 2004, referred to as the Sierra Nevada Framework (USFS 2004). This established an Aquatic Management Strategy with Goals including maintenance and restoration of habitat to support viable populations of riparian-dependent species; spatial and temporal connectivity for aquatic and riparian species within and between watersheds to provide physically, chemically, and biologically unobstructed movement for their survival, migration, and reproduction; instream flows sufficient to sustain desired conditions of riparian, aquatic, wetland, and meadow habitats; the physical structure and condition of streambanks and shorelines to minimize erosion and sustain desired habitat diversity; and prevention of new introductions of invasive species and reduction of invasive species impacts that adversely affect the viability of native species. The Sierra Nevada Framework also includes Riparian Conservation Objectives and associated standards and guidelines specific to aquatic-dependent species, including the Foothill Yellow-legged Frog.

Resource Management Plans

Sequoia, Kings Canyon, and Yosemite National Parks fall within the historical range of the Foothill Yellow-legged Frog, but the species has been extirpated from these areas. The guiding principles for managing biological resources on National Park Service lands include maintenance of animal populations native to park ecosystems (Hayes et al. 2016). They also commit the agency to work with other land managers on regional scientific and planning efforts and maintenance or reintroduction of native species to the parks including conserving Foothill Yellow-legged Frogs in the Sierra Nevada (USDI NPS 1999 as cited in Hayes et al. 2016). A Sequoia and Kings Canyon National Parks Resource Management Plan does not include specific management goals for Foothill Yellow-legged Frogs, but it does include a discussion of the factors leading to the species' decline and measures to restore the integrity of aquatic ecosystems (Ibid.). The Yosemite National Park Resource Management Plan includes a goal of restoring Foothill Yellow-legged Frogs to the Upper Tuolumne River below Hetch Hetchy Reservoir (USDI NPS 2003 as cited in Hayes et al. 2016).

FERC Licenses

Dozens of hydropower dams have been relicensed in California since 1999, and several are in the process of relicensing (FERC 2019). In addition to following the Federal Power Act and other applicable federal laws, Porter-Cologne Water Quality Act requires non-federal dam operators to obtain a Water Quality Certification (WQC) from the SWRCB. Before it can issue the WQC, the SWRCB must consult with

the Department regarding the needs of fish and wildlife. Consequently, SWRCB includes conditions in the WQC that seek to minimize adverse effects to native species, and Foothill Yellow-legged Frogs have received some special considerations due to their sensitivity to dam operations during these licensing processes. As discussed above, the typical outcome is formation of an ERC-type group to implement the environmental compliance requirements and recommend changes to flow management to reduce impacts. Foothill Yellow-legged Frog-specific requirements fall into three general categories: data collection, modified flow regimes, and standard best management practices.

Data Collection

When little is known about the impacts of different flows and temperatures on Foothill Yellow-legged Frog occupancy and breeding success, data are collected and analyzed to inform recommendations for future modifications to operations such as temperature trigger thresholds. These surveys include locating egg masses and tadpoles, monitoring temperatures and flows, and recording their fate (e.g., successful development and metamorphosis, displacement, desiccation) during different flow operations and different water years. Examples of licenses with these conditions include the Lassen Lodge Project (FERC 2018), Rock Creek-Cresta Project (FERC 2009a), and El Dorado Project (EID 2007).

Modified Flow Regimes

When enough data exist to understand the effect of different operations on Foothill Yellow-legged Frog occupancy and success, license conditions may include required minimum seasonal instream flows, specific thermal regimes, gradual ramping rates to reduce the likelihood of early life stage scour or stranding, or freshet releases (winter/spring flooding simulation) to maintain riparian processes, and cancellation or prohibition of recreational pulse flows during the breeding season. Examples of licenses with these conditions include the Poe Hydroelectric Project (SWRCB 2017), Upper American Project (FERC 2014), and Pit 3, 4, 5 Project (FERC 2007b).

Best Management Practices

Efforts to reduce the impacts from maintenance activities and indirect operations include selective herbicide and pesticide application, aquatic invasive species monitoring and control, erosion control, and riparian buffers. Examples of licenses with these conditions include the South Feather Project (SWRCB 2018), Spring Gap-Stanislaus Project (FERC 2009b), and Chili Bar Project (FERC 2007a).

Habitat Conservation Plans and Natural Community Conservation Plans

Non-federal entities can obtain authorization for take of federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of a Habitat Conservation Plan (HCP) pursuant to Section 10 of the ESA. The take authorization can extend to species not currently listed under ESA but which may become listed as threatened or endangered over the term of the HCP, which is often 25-75 years. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. A Natural Community Conservation Plan (NCCP) identifies and provides for the protection of plants, animals, and their

habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs that include Foothill Yellow-legged Frogs as a covered species, two of which are also NCCPs.

HUMBOLDT REDWOOD (FORMERLY PACIFIC LUMBER) COMPANY

The Humboldt Redwood Company (HRC) HCP covers 85,672 ha (211,700 ac) of private Coast Redwood and Douglas-fir forest in Humboldt County (HRC 2015). It is a 50-year HCP/incidental take permit (ITP) that was executed in 1999, revised in 2015 as part of its adaptive management strategy, and expires on March 1, 2049. The HCP includes an Amphibian and Reptile Conservation Plan and an Aquatics Conservation Plan with measures designed to sustain viable populations of Foothill Yellow-legged Frogs and other covered aquatic herpetofauna. These conservation measures include prohibiting or limiting tree harvest within Riparian Management Zones (RMZ), controlling sediment by maintaining roads and hillsides, restricting controlled burns to spring and fall in areas outside of the RMZ, conducting effectiveness monitoring throughout the life of the HCP, and use the data collected to adapt monitoring and management plans accordingly.

Watershed assessment surveys include observations of Foothill Yellow-legged Frogs and have documented their widespread distribution on HRC lands with a pattern of fewer near the coast in the fog belt and more inland (S. Chinnici pers. comm. 2017). The watersheds within the property are largely unaffected by dam-altered flow regimes or non-native species, so aside from the operations described under Timber Harvest above that are minimized to the extent feasible, the focus on suitable temperatures and denser canopy cover for salmonids may reduce habitat suitability for Foothill Yellow-legged Frogs over time (Ibid.).

SAN JOAQUIN COUNTY MULTI-SPECIES HABITAT CONSERVATION AND OPEN SPACE PLAN

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) is a 50-year HCP/ITP that was signed by the USFWS on November 14, 2000 (San Joaquin County 2000). The SJMSCP covers almost all of San Joaquin County except federal lands, a few select projects, and some properties with certain land uses, roughly 364,000 ha (900,000 ac). At the time of execution, approximately 70 ha (172 ac) of habitat within the SJMSCP area in the southwest portion of the county were considered occupied by Foothill Yellow-legged Frogs with another 1,815 ha (4,484 ac) classified as potential habitat, but it appears the species had been considered extirpated before then (Jennings and Hayes 1994, San Joaquin County 2000, Lind 2005). The HCP estimates around 8% of the combined modeled habitat would be converted to other uses over the permit term, but the establishment of riparian preserves with buffers around Corral Hollow Creek, where the species occurred historically, was expected to offset those impacts (San Joaquin County 2000, SJCOG 2018). However, the HCP did not require surveys to determine if Foothill Yellow-legged Frogs are benefiting (M. Grefsrud pers. comm. 2019).

EAST CONTRA COSTA COUNTY HABITAT CONSERVATION PLAN/NATURAL COMMUNITY CONSERVATION PLAN

The East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan (ECCC HCP/NCCP) is a multi-jurisdictional 30-year plan adopted in 2007 that covers over 70,423 ha (174,018 ac) in eastern Contra Costa County (Jones & Stokes 2006). The Foothill Yellow-legged Frog appears to be

extirpated from the ECCC HCP/NCCP area (CNDDB 2019). Nevertheless, suitable habitat was mapped, and impacts were estimated at well under 1% of both breeding and migratory habitat (Jones & Stokes 2006). One of the HCP/NCCP's objectives is acquiring high-quality Foothill Yellow-legged Frog habitat that has been identified along Marsh Creek (Ibid.). In 2017, the Viera North Peak 65 ha (160 ac) property was acquired that possesses suitable habitat for Foothill Yellow-legged Frogs (ECCCHC 2018).

SANTA CLARA VALLEY HABITAT PLAN

The Santa Clara Valley Habitat Plan (SCVHP) is a 50-year HCP/NCCP covering over 210,237 ha (519,506 ac) in Santa Clara County (ICF 2012). As previously mentioned, Foothill Yellow-legged Frogs appear to have been extirpated from lower elevation sites, particularly below reservoirs in this area. Approximately 17% of modeled Foothill Yellow-legged Frog habitat, measured linearly along streams, was already permanently preserved, and the SCVHP seeks to increase that to 32%. The maximum allowable habitat loss is 11 km (7 mi) permanent loss and 3 km (2 mi) temporary loss, while 167 km (104 mi) of modeled habitat is slated for protection. By mid-2018, 8% of impact area had been accrued and 3% of habitat protected (SCVHA 2019).

GREEN DIAMOND AQUATIC HABITAT CONSERVATION PLAN

Green Diamond Resources Company has an Aquatic Habitat Conservation Plan (AHCP) covering 161,875 ha (400,000 ac) of their land that is focused on cold-water adapted species, but many of the conservation measures are expected to benefit Foothill Yellow-legged Frogs as well (K. Hamm pers. comm. 2017). Examples include slope stability and road management measures to reduce stream sedimentation from erosion and landslides, and limiting water drafting during low flow periods with screens over the pumps to avoid entraining animals (Ibid.). Although creating more open canopy areas and warmer water temperatures is not the goal of the AHCP, the areas that are suitable for Foothill Yellow-legged Frog breeding are likely to remain that way because they are wide channels that receive sufficient sunlight (Ibid.).

SUMMARY OF LISTING FACTORS

CESA's implementing regulations identify key factors relevant to the Department's analyses and the Fish and Game Commission's decision on whether to list a species as threatened or endangered. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

Present or Threatened Modification or Destruction of Habitat

Most of the factors affecting ability to survive and reproduce listed above involve destruction or degradation of Foothill Yellow-legged Frog habitat. The most widespread, and potentially most significant, threats are associated with dams and their flow regimes, particularly in areas where they are concentrated and occur in a series along a river. Dams and the way they are operated can have up- and downstream impacts to Foothill Yellow-legged Frogs. They can result in ~~confusing~~ aseasonal or asynchronous ~~natural~~ breeding cues, scouring and stranding of egg masses and tadpoles, reducing quality and quantity of breeding and rearing habitat, reducing tadpole growth rate, impeding gene flow among populations, and establishing and spreading non-native species (Hayes et al. 2016). These impacts appear to be most severe when the dam is operated for the generation of hydropower utilizing hydropeaking and pulse flows (Kupferberg et al. 2009c, Peek 2018). Foothill Yellow-legged Frog abundance below dams is an average of five times lower than in unregulated rivers (Kupferberg et al. 2012). The number, height, and distance upstream of dams in a watershed influenced whether Foothill Yellow-legged Frogs still occurred at sites where they had been present in 1975 in California (Ibid.). Water diversions for agricultural, industrial, and municipal uses also reduce the availability and quality of Foothill Yellow-legged Frog habitat. Dams are concentrated in the Bay Area, Sierra Nevada, and southern California (Figure 17), while hydropower plants are densest in the northern and central Sierra Nevada (Figure 18).

With predicted increases in the human population, ambitious renewable energy targets, higher temperatures, and more extreme and variable precipitation falling increasingly more as rain rather than snow, the need for more and taller dams and water diversions for hydroelectric power generation, flood control, and water storage and delivery is not expected to abate in the future. California voters approved Proposition 1, the Water Quality, Supply and Infrastructure Improvement Act of 2014, which dedicated $2.7 billion to water storage projects (PPIC 2018). In 2018, the California Water Commission approved funding for four new dams in California: expansion of Pacheco Reservoir (Santa Clara County), expansion of Los Vaqueros Reservoir (Contra Costa County), Temperance Flat Dam (new construction) on the San Joaquin River (Fresno County), and the off-stream Sites Reservoir (new construction) diverting the Sacramento River (Colusa County) (CWC 2019). No historical records of Foothill Yellow-legged Frogs from the Los Vaqueros or Sites Reservoir areas exist in the CNDDB, and one historical (1950) collection is documented from the Pacheco Reservoir area (CNDDB 2019). However, the proposed Temperance Flat Dam site is downstream of one of the only known extant populations of Foothill Yellow-legged Frogs in the East/Southern Sierra clade (Ibid.).

The other widespread threat to Foothill Yellow-legged Frog habitat is climate change, although the severity of its impacts is somewhat uncertain. While drought, wildland fires, floods, and landslides are natural and ostensibly necessary disturbance events for preservation of native biodiversity, climate change is expected to result in increased frequency and severity of these events in ways that may exceed species' abilities to adapt (Williams et al. 2008, Hoffmann and Sgrò 2011, Keely and Syphard 2016). These changes can lead to increased competition, predation, and disease transmission as species become concentrated in areas that remain wet into the late summer (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Loss of riparian vegetation from wildland fires can result in increased stream temperatures or concentrations of nutrients and trace heavy metals that inhibit growth and survival (Spencer and Hauer 1991, Megahan et al. 1995, Burton et al. 2016). Stream sedimentation from landslides following fire or excessive precipitation can destroy or degrade breeding and rearing habitat (Harvey and Lisle 1998, Olson and Davis 2009, Kupferberg et al. 2011b). At least some models predict unprecedented dryness in the latter half of the century (Cook et al. 2015). The effects of climate change will be realized across the Foothill Yellow-legged Frog's range, and thetheir severity of these effects will likely differ in ways that are difficult to predict. However, the impacts from extended droughts will likely be greatest in the areas that are naturally more arid, the lower elevations and latitudes of southern California and the foothills surrounding the Central Valley (Figure 21).

While most future urbanization is predicted to occur in areas outside of the Foothill Yellow-legged Frog's range, it has already contributed to the loss and fragmentation of Foothill Yellow-legged Frog habitat in California. In addition, the increased predation, wildland fires, introduced species, road mortality, disease transmission, air and water pollution, and disturbance from recreation that can accompany urbanization expand its impact far beyond its physical footprint (Davidson et al. 2002, Syphard et al. 2007, Cook et al. 2012, Bar-Massada et al. 2014). Within the Foothill Yellow-legged Frog's historical range, these effects appear most significant and extensive in terms of population extirpations in southern California and the San Francisco Bay Area.

Several other activities have the potential to destroy or degrade Foothill Yellow-legged Frog habitat, but they are less common across the range. They also tend to have relatively small areas of impact, although they can be significant in those areas, particularly if populations are already small and declining. These include impacts from mining, cannabis cultivation, vineyard expansion, overgrazing, timber harvest, recreation, and some stream habitat restoration projects (Harvey and Lisle 1998, Belsky et al. 1999, Merelender 2000, Pilliod et al. 2003, Bauer et al. 2015, Kupferberg and Furey 2015).

Overexploitation

Foothill Yellow-legged Frogs are not threatened by overexploitation. There is no known pet trade for Foothill Yellow-legged Frogs (Lind 2005). During the massive frog harvest that accompanied the Gold Rush, some Foothill Yellow-legged Frogs were collected, but because they are relatively small and have irritating skin secretions, there was much less of a market for them (Jennings and Hayes 1985). Within these secretions is a peptide with antimicrobial activity that is particularly potent against *Candida albicans*, a human pathogen that has been developing resistance to traditional antifungal agents (Conlon et al. 2003). However, the peptide's therapeutic potential is limited by its strong hemolytic activity, so further studies will focus on synthesizing analogs that can be used as antifungals, and collection of Foothill Yellow-legged Frogs for lab cultures is unlikely (Ibid.).

Like all native California amphibians, collection of Foothill Yellow-legged Frogs is unlawful without a permit from the Department. They may only be collected for scientific, educational, or propagation reasons through a Scientific Collecting Permit (Fish & G. Code § 1002 et seq.). The Department has the discretion to limit or condition the number of individuals collected or handled to ensure no significant adverse effects. Incidental harm from authorized activities on other aquatic species can be avoided or minimized by the inclusion of special terms and conditions in permits.

Predation

Predation is a likely contributor to Foothill Yellow-legged Frog population declines where the habitat is degraded by one or many other risk factors (Hayes and Jennings 1986). Predation by native gartersnakes can be locally substantial; however, it may only have an appreciable population-level impact if the availability of escape refugia is diminished. For example, when streams dry and only pools remain, Foothill Yellow-legged Frogs are more vulnerable to predation by native and non-native species because they are concentrated in a small area with little aquatic cover.

Several studies have demonstrated the synergistic impacts of predators and other stressors. Foothill Yellow-legged Frogs, primarily as demonstrated through studies on tadpoles, are more susceptible to predation when exposed to some agrochemicals, cold water, high velocities, excess sedimentation, and even the presence of other species of predators (Harvey and Lisle 1998, Adams et al. 2003, Olson and Davis 2009, Kupferberg et al. 2011b, Kerby and Sih 2015, Catenazzi and Kupferberg 2018). Foothill Yellow-legged Frog tadpoles appear to be naïve to chemical cues from some non-native predators; they have not evolved those species-specific predator avoidance behaviors (Paoletti et al. 2011). Furthermore, early life stages are often more sensitive to environmental stressors, making them more vulnerable to predation, and Foothill Yellow-legged Frog population dynamics are highly sensitive to egg and tadpole mortality (Kats and Ferrer, 2003, Kupferberg et al. 2009c). Predation pressure is likely positively associated with proximity to anthropogenic changes in the environment, so in more remote or pristine places, it probably does not have a serious population-level impact.

Competition

Intra- and interspecific competition in Foothill Yellow-legged Frogs has been documented. Intraspecific male-to-male competition for females has been reported (Rombough and Hayes 2007). Observations include physical aggression and a non-random mating pattern in which larger males were more often engaged in breeding (Rombough and Hayes 2007, Wheeler and Welsh 2008). A behavior resembling clutch-piracy, where a satellite male attempts to fertilize already laid eggs, has also been documented (Rombough and Hayes 2007). These acts of competition play a role in population genetics, but they likely do not result in serious physical injury or mortality. Intraspecific competition among Foothill Yellow-legged Frog tadpoles was negligible (Kupferberg 1997a).

Interspecific competition appears to have a greater possibility of resulting in adverse impacts. Kupferberg (1997a) did not observe a significant change in tadpole mortality for Foothill Yellow-legged Frogs raised with Pacific Treefrogs compared to single-species controls. However, when reared together, Foothill Yellow-legged Frog tadpoles lost mass, while Pacific Treefrog tadpoles increased mass (Kerby and Sih 2015). As described previously under Introduced Species, Foothill Yellow-legged Frog tadpoles experienced significantly higher mortality and smaller size at metamorphosis when raised with bullfrog tadpoles (Kupferberg 1997a). The mechanism of these declines appeared to be exploitative competition, as opposed to interference, through the reduction of available algal resources from bullfrog tadpole grazing in the shared enclosures (Ibid.).

The degree to which competition threatens Foothill Yellow-legged Frogs likely depends on the number and density of non-native species in the area rather than intraspecific competition, and co-occurrence of Foothill Yellow-legged Frog and bullfrog tadpoles may be somewhat rare since the latter tends to breed in lentic (still water) environments (M. van Hattem pers. comm. 2019). Interspecific competition with other native species may have some minor adverse consequences on fitness.

Disease

Currently, the only disease known to pose a serious risk to Foothill Yellow-legged Frogs is Bd. Until 2017, the only published studies on the impact of Bd on Foothill Yellow-legged Frog suggested it could reduce growth and body condition but was not lethal (Davidson et al. 2007, Lowe 2009, Adams et al. 2017b). However, two recent mass mortality events caused by chytridiomycosis proved they are susceptible to lethal effects, at least under certain conditions like drought-related concentration and presence of bullfrogs (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Some evidence indicates disease may have played a principal role in the disappearance of the species from southern California (Adams et al. 2017b). Bd is likely present in the environmental throughout the Foothill Yellow-legged Frog's range, and with bullfrogs and treefrogs acting as carriers, it will remain a threat to the species; however, given the dynamics of the two recent die-offs in the San Francisco Bay area, the probability of future outbreaks may be greater in areas where the species is under additional stressors like drought and introduced species (Adams et al. 2017a, Kupferberg and Catenazzi 2019). Therefore, as with predation, Foothill Yellow-legged Frogs are less likely to experience the adverse impacts of diseases in more remote areas with fewer anthropogenic changes to the environment.

Other Natural Events or Human-Related Activities

Agrochemicals, particularly organophosphates that act as endocrine disruptors, can travel substantial distances from the area of application through atmospheric drift and have been implicated in the disappearance and declines of many species of amphibians in California including Foothill Yellow-legged Frogs (LeNoir et al. 1999, Davidson 2004, Lind 2005, Olson and Davis 2009). Foothill Yellow-legged Frogs appear to be significantly more sensitive to the adverse impacts of some pesticides than other native species (Sparling and Fellers 2009, Kerby and Sih 2015). These include smaller body size, slower development rate, increased time to metamorphosis, immunosuppression, and greater vulnerability to predation and malformations (Kiesecker 2002, Hayes et al. 2006, Sparling and Fellers 2009, Kerby and Sih 2015). Some of the most dramatic declines experienced by ranids in California occurred in the Sierra Nevada east of the San Joaquin Valley where over half of the state's total pesticide usage occurs (Sparling et al. 2001).

Many Foothill Yellow-legged Frog populations are small, isolated from other populations, and possess low genetic diversity (McCartney-Melstad et al. 2018, Peek 2018). Genetic diversity is important in providing a population the capacity to evolve in response to environmental changes, and connectivity among populations is important for gene exchange and in minimizing probability of local extinction

(Lande and Shannon 1996, Williams et al. 2008, Eriksson et al. 2014). Small populations are at much greater risk of extirpation primarily through the disproportionate impact of demographic, environmental, and genetic stochasticity than robust populations (Lande and Shannon 1996, Palstra and Ruzzante 2008). Based on a Foothill Yellow-legged Frog PVA, populations in regulated rivers face a 4- to 13-fold greater extinction risk in 30 years than populations in unregulated rivers due to smaller population sizes (Kupferberg et al. 2009c). The threat posed by small population sizes is significant and the general pattern shows increases in severity from north to south; however, many sites, primarily in the northern Sierra Nevada, in watersheds with large hydropower projects are also at high risk.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). The conservation, protection, and enhancement of listed species and their habitat is of statewide concern (Fish & G. Code, § 2051(c)). CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86). The Fish and Game Code provides the Department with related authority to authorize "take" of species listed as threatened or endangered under certain circumstances (see, e.g., Fish & G. Code, §§ 2081, 2081.1, 2086, & 2835).

If the Foothill Yellow-legged Frog is listed under CESA, impacts of take caused by activities authorized through incidental take permits must be minimized and fully mitigated according to state standards (Fish & G. Code, § 2081, subd. (b)). These standards typically include protection of land in perpetuity with an easement, development and implementation of a species-specific adaptive management plan, and funding through an endowment to pay for long-term monitoring and maintenance to ensure the mitigation land meets performance criteria. Obtaining an incidental take permit is voluntary. The Department cannot force compliance; however, any person violating the take prohibition may be criminally and civilly liable under state law.

Additional protection of Foothill Yellow-legged Frogs following listing would be expected to occur through state and local agency environmental review under CEQA. CEQA requires affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on rare, threatened, and endangered species. In common practice, potential impacts to listed species are examined more closely in CEQA documents than potential impacts to unlisted species. Where significant impacts are identified under CEQA, the Department expects project-specific avoidance, minimization, and mitigation measures to benefit the species. State listing, in this respect, and consultation with the Department during state and local agency environmental review under CEQA, would be expected to benefit the Foothill Yellow-legged Frog in terms of reducing impacts from individual projects, which might otherwise occur absent listing.

For some species, CESA listing may prompt increased interagency coordination and the likelihood that state and federal land and resource management agencies will allocate funds toward protection and recovery actions. In the case of the Foothill Yellow-legged Frog, some multi-agency efforts exist, often associated with FERC license requirements, to improve habitat conditions and augment declining populations. The USFWS is leading an effort to develop regional Foothill Yellow-legged Frog conservation strategies, and CESA listing may result in increased priority for limited conservation funds.

LISTING RECOMMENDATION

CESA directs the Department to prepare this report regarding the status of the Foothill Yellow-legged Frog in California based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067).

The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science. In consideration of the scientific information contained herein, the Department has determined that listing the Foothill Yellow-legged Frog under CESA by genetic clade is the prudent approach due to the disparate degrees of imperilment among them. In areas of uncertainty, the Department recommends the higher protection status until clade boundaries can be better defined.

NORTHWEST/NORTH COAST: Not warranted at this time.

Clade-level Summary: This is the largest clade with the most robust populations (highest densities) and the greatest genetic diversity. This area is the least densely populated by humans; contains relatively few hydroelectric dams, particularly further north; and has the highest precipitation in the species' California range. The species is still known to occur in most, if not all, historically occupied watersheds; presumed extirpations are mainly concentrated in the southern portion of the clade around the heavily urbanized San Francisco Bay area. The proliferation of cannabis cultivation, particularly illicit grows in and around the Emerald Triangle, the apparent increase in severe wildland fires in the area, and potential climate change effects are cause for concern, so the species should remain a Priority 1 SSC here with continued monitoring for any change in its status.

WEST/CENTRAL COAST: Endangered.

Clade-level Summary: Foothill Yellow-legged Frogs appear to be extirpated from a relatively large proportion of historically occupied sites within this clade, particularly in the heavily urbanized northern portion around the San Francisco Bay. In the northern portion of the clade, nearly all the remaining populations (which may be fewer than a dozen) are located above dams, which line the mountains surrounding the Bay Area, and two are known to have undergone recent disease-associated die-offs. These higher elevation sites are more often intermittent or ephemeral streams than the lower in the watersheds. As a result, the more frequent and extreme droughts that have dried up large areas seem to have contributed to recent declines. Illegal cannabis cultivation, historical mining effects, overgrazing, and recreation likely contributed to declines and may continue to threaten remaining populations.

SOUTHWEST/SOUTH COAST: Endangered.

Clade-level Summary: The most extensive extirpations have occurred in this clade, and only two known extant populations remain. Both are small with apparently low genetic diversity, making them especially vulnerable to extirpation. This is also an area with a large human population, many dams, and naturally arid, fire-prone environments, particularly in the southern portion of the clade. Introduced species are widespread, and cannabis cultivation is rivaling the Emerald Triangle in some areas (e.g., Santa Barbara County). Introduced species, expanded recreation, disease, and flooding appear to have contributed to the widespread extirpations in southern California over 40 years ago.

FEATHER RIVER: Threatened.

Clade-level Summary: This is the smallest clade and has a high density of hydroelectric dams. It also recently experienced one of the largest, most catastrophic wildfires in California history. Despite these threats, Foothill Yellow-legged Frogs appear to continue to be relatively broadly distributed within the clade, although with all the dams in the area, most populations are likely disconnected. The area is more mesic and experienced less of a change in precipitation in the most recent drought than the clades south of it. The clade is remarkable genetically and morphologically as it is the only area where Foothill Yellow-legged Frogs and Sierra Nevada Yellow-legged Frogs overlap and can hybridize. The genetic variation within the clade is greater than the other clades except for the Northwest/North Coast. Most of the area within the clade's boundaries is Forest Service-managed, and little urbanization pressure or known extirpations exist in this area. Recent FERC licenses in this area require Foothill Yellow-legged Frog specific conservation, which to date has included cancelling pulse flows, removing encroaching vegetation, and translocating egg masses and in situ head-starting to augment a population that had recently declined.

NORTHEAST/NORTHERN SIERRA: Threatened.

Clade-level Summary: The Northeast/Northern Sierra clade shares many of the same threats as the Feather River clade (e.g., relatively small area with many hydroelectric dams). The area is also more mesic and experienced less of a change in precipitation during the recent drought than more southern clades. However, this pattern may not continue as some models suggest loss of snowmelt will be greater in the northern Sierra Nevada, and one of the climate change exposure models suggests a comparatively large proportion of the lower elevations will experience climatic conditions not currently known from the area (i.e., non-analog) by the end of the century. Recent surveys suggest the area continues to support several populations of the species, some of which seem to remain robust, with a fairly widespread distribution. However, genetic analyses from several watersheds suggest many of these populations are isolated and diverging, particularly in regulated reaches with hydropeaking flows.

EAST/SOUTHERN SIERRA: Endangered.

Clade-level Summary: Like the Southwest/South Coast clade, widespread extirpations in this area were observed as early as the 1970s. Dams and introduced species were credited as causal factors in these declines in distribution and abundance, and mining and disease may also have contributed. This area is relatively arid, and drought effects appear greater here than in northern areas that exhibit both more precipitation and a smaller difference between drought years and the historical average. There is a relatively high number of hydroelectric power generating dams in series along the major rivers in this clade and at least one new proposed dam near one of the remaining populations. This area is also the most heavily impacted by agrochemicals from the San Joaquin Valley.

Commented [RAP19]: Just realizing the use of hydropower, hydroelectric and hydroelectric power may benefit from one global term. It seems to switch around throughout, and ultimately all means the same…for simplicity I'd recommend using "hydropower" globally.

MANAGEMENT RECOMMENDATIONS

The Department has evaluated existing management recommendations and available literature applicable to the management and conservation of the Foothill Yellow-legged Frog to arrive at the following recommendations. These recommendations, which represent the best available scientific information, are largely derived the from the Foothill Yellow-legged Frog Conservation Assessment, the California Energy Commission's Public Interest Energy Research Reports, the Recovery Plans of West Coast Salmon and Steelhead, and the California Amphibian and Reptile Species of Special Concern (Kupferberg et al. 2009b,c; 2011a; NMFS 2012, 2013, 2014, 2016; Hayes et al. 2016, Thomson et al. 2016).

Conservation Strategies

Maintain current distribution and genetic diversity by protecting existing Foothill Yellow-legged Frog populations and their habitats and providing opportunities for increased connectivity and ~~genetic exchange~~gene flow. Increase abundance to viable levels in populations at risk of extirpation due to small sizes, when appropriate, through in situ or ex situ captive rearing and/or translocations. Use habitat suitability and hydrodynamic habitat models to identify historically occupied sites that may currently support Foothill Yellow-legged Frogs, or they could with minor habitat improvements or modified management. Re-establish extirpated populations in suitable habitat through captive propagation, rearing, and/or translocations. Prioritize areas in the southern portions of the species' range where extirpations and loss of diversity have been the most severe.

If establishing reserves, prioritize areas containing high genetic variation in Foothill Yellow-legged Frogs (and among various native species) and climatic gradients where selection varies over small geographical area. ~~because e~~Environmental heterogeneity can provide a means of maintaining phenotypic variability, which increases the adaptive capacity of populations as conditions change. These reserves should provide connectivity to other occupied areas to facilitate gene flow and allow for ongoing selection to fire, drought, thermal stresses, and changing species interactions.

Commented [RAP20]: Great sentence but should split it up into two parts.

Research and Monitoring

Attempt to rediscover potentially remnant populations in areas where they are considered extirpated, prioritizing the southern portions of the species' range. Collect environmental DNA in addition to conducting visual encounter surveys to improve detectability. Concurrently assess presence of threats and habitat suitability to determine if future reintroductions may be possible. Collect genetic samples from any Foothill Yellow-legged Frogs captured for use in landscape genomics analyses and possible future translocation or captive propagation efforts. Attempt to better clarify clade boundaries where there is uncertainty. Study whether small populations are at risk of inbreeding depression, whether genetic rescue should be attempted, and if so, whether that results in hybrid vigor or outbreeding depression.

Continue to evaluate how water operations affect Foothill Yellow-legged Frog population demographics. Establish more long-term monitoring programs in regulated and unregulated (reference) rivers across the species' range but particularly in areas like the Sierra Nevada where most large hydropower dams in the species' range are concentrated. Assess whether the timing of pulse flows influences population dynamics, particularly whether early releases have a disproportionately large adverse effect by eliminating the reproductive success of the largest, most fecund females, who appear to breed earlier in the season. Investigate survival rates in poorly-understood life stages, such as tadpoles, young of the year, and juveniles. Determine the extent to which pulse flows contribute to displacement and mortality of post-metamorphic life stages.

Collect habitat variables that correlate with healthy populations to develop more site-specific habitat suitability and hydrodynamic models. Study the potential synergistic effect of increased flow velocity and decreased temperature on tadpole fitness. Examine the relationship between changes in flow, breeding and rearing habitat connectivity, and scouring and stranding to develop site-specific benign ramping rates. Incorporate these data and demographic data into future PVAs for use in establishing frog-friendly flow regimes in future FERC relicensing or license amendment efforts and habitat restoration projects. Ensure long-term funding for post-license or restoration monitoring to evaluate attainment of expected results and for use in adapting management strategies accordingly.

Evaluate the distribution of other threats such as cannabis cultivation, vineyard expansion, livestock grazing, mining, timber harvest, and urbanization and roads in the Foothill Yellow-legged Frog's range. Study the short- and long-term effects of wildland fires and fire management strategies. Assess the extent to which these potential threats pose a risk to Foothill Yellow-legged Frog persistence in both regulated and unregulated systems.

Investigate how reach-level or short-distance habitat suitability and hydrodynamic models can be extrapolated to a watershed level. Study habitat connectivity needs such as the proximity of breeding sites and other suitable habitats along a waterway necessary to maintain gene flow and functioning meta-population dynamics.

Habitat Restoration and Watershed Management

Remove or update physical barriers like dams and poorly constructed culverts and bridges to improve connectivity and natural stream processes. Remove anthropogenic features that support introduced predators and competitors such as abandoned mine tailing ponds that support bullfrog breeding. Conduct active eradication and management efforts to decrease the abundance of bullfrogs, non-native fish, and crayfish (where they are non-native). In managed rivers, manipulate stream flows to negatively affect non-native species not adapted to a winter flood/summer drought flow regime.

Adopt a multi-species approach to channel restoration projects and managed flow regimes (thermal, velocity, timing) and mimic the natural hydrograph to the greatest extent possible. When this is impractical or infeasible, focus on minimizing adverse impacts by gradually ramping discharge up and down, creating and maintaining gently sloping and sun-lit gravel bars and warm calm edgewater habitats for tadpole rearing, and mixing hypolimnetic water (from the lower colder stratum in a reservoir) with warmer surface water before release if necessary to ensure appropriate thermal conditions for successful metamorphosis. Promote restoration and maintenance of habitat heterogeneity (different depths, velocities, substrates, etc.) and connectivity to support all life stages and gene flow. Avoid damaging Foothill Yellow-legged Frog breeding habitat when restoring habitat for other focal species like anadromous salmonids.

Regulatory Considerations and Best Management Practices

Develop range-wide minimum summer baseflow requirements that protect Foothill Yellow-legged Frogs and their habitat with appropriate provisions to address regional differences using new more ecologically-meaningful approaches such as modified percent-of-flow strategies for watersheds (e.g., Mierau et al. 2018). Limit water diversions during the dry season and construction of new dams by focusing on off-stream water storage strategies.

Ensure and improve protection of riparian systems. Require maintenance of appropriate riparian buffers and canopy coverage (i.e., partly shaded) around occupied habitat or habitat that has been identified for potential future reintroductions. Restrict instream work to dry periods where possible. Prohibit fording in and around breeding habitat. Avoid working near streams after the first major rains in the fall when Foothill Yellow-legged Frogs may be moving upslope toward tributaries and overwintering sites. Use a 3 mm (0.125 in) mesh screen on water diversion pumps and limit the rate and amount of water diverted such that depth and flow remain sufficient to support Foothill Yellow-legged Frogs of all life stages occupying the immediate area and downstream. Install exclusion fencing where appropriate, and if Foothill Yellow-legged Frog relocation is required, conduct it early in the season because moving egg masses is easier than moving tadpoles.

Reduce habitat degradation from sedimentation, pesticides, herbicides, and other non-point source waste discharges from adjacent land uses including along tributaries of rivers and streams. Limit mining to parts of rivers not used for oviposition, such as deeper pools or reaches with few tributaries, and at times of year when frogs are more common in tributaries (i.e., fall and winter). Manage recreational activities in or adjacent to Foothill Yellow-legged Frog habitat (e.g., OHV and hiking trails, camp sites, boating ingress/egress, flows, and speeds) in a way that minimizes adverse impacts. Siting cannabis grows in areas with better access to roads, gentler slopes, and ample water resources could significantly reduce threats to the environment. Determine which, when, and where agrochemicals should be restricted to reduce harm to Foothill Yellow-legged Frogs and other species. Ensure all new road crossings and upgrades to existing crossings (bridges, culverts, fills, and other crossings) accommodate at least 100-year flood flows and associated bedload and debris.

Partnerships and Coordination

Establish collaborative partnerships with agencies, universities, and non-governmental organizations working on salmon and steelhead recovery and stream restoration. Anadromous salmonids share many of the same threats as Foothill Yellow-legged Frogs, and recovery actions such as barrier removal, restoration of natural sediment transport processes, reduction in pollution, and eradication of non-native predators would benefit frogs as well. Ensure Integrated Regional Water Management Plans and fisheries restoration programs take Foothill Yellow-legged Frog conservation into consideration during design, implementation, and maintenance.

Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems. Promote and implement initiatives and programs that improve water conservation use efficiency, reduce greenhouse gas emissions, promote sustainable agriculture and smart urban growth, and protect and restore riparian ecosystems. Shift reliance from on-stream storage to off-stream storage, resolve frost protection issues (water withdrawals), and ensure necessary flows for all life stages in all water years.

Establish a Department-coordinated staff and citizen scientist program to systematically monitor occupied stream reaches across the species' range.

Education and Enforcement

Support programs to provide educational outreach and local involvement in restoration and watershed stewardship, such as Project Wild, Adopt a Watershed, school district environmental camps, and other programs teaching the effects of human land and water use on Foothill Yellow-legged Frog survival.

Provide additional funding for increased law enforcement to reduce ecologically harmful stream alterations and water pollution and to ensure adequate protection for Foothill Yellow-legged Frogs at pumps and diversions. Identify and address illegal water diverters and out-of-compliance diverters, seasons of diversion, off-stream reservoirs, well pumping, and bypass flows to protect Foothill Yellow-legged Frogs. Prosecute violators accordingly.

ECONOMIC CONSIDERATIONS

The Department is charged in an advisory capacity in the present context to provide a written report and a related recommendation to the Commission based on the best scientific information available regarding the status of Foothill Yellow-legged Frog in California. The Department is not required to prepare an analysis of economic impacts (See Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

REFERENCES

Literature Cited

Ackerly, D., A. Jones, M. Stacey, and B. Riordan. 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.

Adams, A.J., S.J. Kupferberg, M.Q. Wilber, A.P. Pessier, M. Grefsrud, S. Bobzien, V.T. Vredenburg, and C.J. Briggs. 2017a. Extreme Drought, Host Density, Sex, and Bullfrogs Influence Fungal Pathogen Infections in a Declining Lotic Amphibian. Ecosphere 8(3):e01740. DOI: 10.1002/ecs2.1740.

Adams, A.J., A.P. Pessier, and C.J. Briggs. 2017b. Rapid Extirpation of a North American Frog Coincides with an Increase in Fungal Pathogen Prevalence: Historical Analysis and Implications for Reintroduction. Ecology and Evolution 7(23):10216-10232. DOI: 10.1002/ece3.3468

Adams, M.J., C.A. Pearl, and R.B. Bury. 2003. Indirect Facilitation of an Anuran Invasion by Non-native Fishes. Ecology Letters 6:343-351.

Allen, M., and S. Riley. 2012. Effects of Electrofishing on Adult Frogs. Unpublished report prepared by Normandeau Associates, Inc., Arcata, CA.

Alpers, C.N., M.P. Hunerlach, J.T. May, R.L. Hothem, H.E. Taylor, R.C. Antweiler, J.F. De Wild, and D.A. Lawler. 2005. Geochemical Characterization of Water, Sediment, and Biota Affected by Mercury Contamination and Acidic Drainage from Historical Gold Mining, Greenhorn Creek, Nevada County, California, 1999–2001: U.S. Geological Survey Scientific Investigations Report 2004-5251.

Alston, J.M., J.T. Lapsley, and O. Sambucci. 2018. Grape and Wine Production in California. Pp. 1-28 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California. https://s.giannini.ucop.edu/uploads/giannini_public/a1/1e/a11eb90f-af2a-4deb-ae58-9af60ce6aa40/grape_and_wine_production.pdf

American Bankers Association [ABA]. 2019. Marijuana and Banking. Website accessed on April 5, 2019 at https://www.aba.com/advocacy/issues/pages/marijuana-banking.aspx

Ashton, D.T. 2002. A Comparison of Abundance and Assemblage of Lotic Amphibians in Late-Seral and Second-Growth Redwood Forests in Humboldt County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Ashton, D.T., J.B. Bettaso, and H.H. Welsh, Jr. 2010. Foothill Yellow-legged Frog (*Rana boylii*) Distribution and Phenology Relative to Flow Management on the Trinity River. Oral presentation provided at the Trinity River Restoration Program's 2010 Trinity River Science Symposium 13 January 2010. http://www.trrp.net/library/document/?id=410

Ashton, D.T., A.J. Lind, and K.E. Schlick. 1997. Foothill Yellow-Legged Frog (*Rana boylii*) Natural History. USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, CA.

Ashton, D.T., and R.J. Nakamoto. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 38(4):442.

Baird, S.F. 1854. Descriptions of New Genera and Species of North American Frogs. Proceedings of the Academy of Natural Sciences of Philadelphia 7:62.

Bar-Massada, A., V.C. Radeloff, and S.I. Stewart. 2014. Biotic and Abiotic Effects of Human Settlements in the Wildland–Urban Interface. BioScience 64(5):429–437.

Bauer S.D., J.L. Olson, A.C. Cockrill, M.G. van Hattem, L.M. Miller, M. Tauzer, and G. Leppig. 2015. Impacts of Surface Water Diversions for Marijuana-Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLoS ONE 10(3):e0120016. https://doi.org/10.1371/journal.pone.0120016

Bee, M.A., and E.M. Swanson. 2007. Auditory Masking of Anuran Advertisement Calls by Road Traffic Noise. Animal Behaviour 74:1765-1776.

Beebee, T.J.C. 1995. Amphibian Breeding and Climate. Nature 374:219-220.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing in the Riparian Zone: Impact and Management Perspectives. Pp. 184-189 *In* R.D. Johnson and J.F. McCormick (Technical Coordinators). Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, U.S. Department of Agriculture, Forest Service, General Technical Report WO-12.

Belsky, A.J, A. Matzke, and S. Uselman. 1999. Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States. Journal of Soil and Water Conservation 54(1):419-431.

Blaustein, A.R., D.G. Hokit, R.K. O'Hara and R.A. Holt. 1994. Pathogenic Fungus Contributes to Amphibian Losses in the Pacific Northwest. Biological Conservation 67(3):251-254.

Bobzien, S., and J.E. DiDonato. 2007. The Status of the California Tiger Salamander (*Ambystoma californiense*), California Red-Legged Frog (*Rana draytonii*), Foothill Yellow-Legged Frog (*Rana boylii*), and Other Aquatic Herpetofauna in the East Bay Regional Park District, California. Unpublished report. East Bay Regional Park District, Oakland, CA.

Bondi, C.A., S.M. Yarnell, and A.J. Lind. 2013. Transferability of Habitat Suitability Criteria for a Stream Breeding Frog (*Rana boylii*) in the Sierra Nevada, California. Herpetological Conservation and Biology 8(1):88-103.

Bourque, R.M. 2008. Spatial Ecology of an Inland Population of the Foothill Yellow-Legged Frog (*Rana boylii*) in Tehama County, California. Master's Thesis, Humboldt State University, Arcata, CA.

Bourque, R.M., and J.B. Bettaso. 2011. *Rana boylii* (Foothill Yellow-legged Frogs). Reproduction. Herpetological Review 42(4):589.

Brattstrom, B.H. 1962. Thermal Control of Aggregation Behavior in Tadpoles. Herpetologica 18(1):38-46.

Breedvelt, K.G.H., and M.J. Ellis. 2018. Foothill Yellow-legged Frog (*Rana boylii*) Growth, Longevity, and Population Dynamics from a 9-Year Photographic Capture-Recapture Study. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Brehme, C.S., S.A. Hathaway, and R.N. Fisher. 2018. An Objective Road Risk Assessment Method for Multiple Species: Ranking 166 Reptiles and Amphibians in California. Landscape Ecology 33:911-935. DOI: 10.1007/s10980-018-0640-1

Brode, J.M., and R.B. Bury. 1984. The Importance of Riparian Systems to Amphibians and Reptiles. Pp. 30-36 *In* R. E. Warner and K. M. Hendrix (Editors). Proceedings of the California Riparian Systems Conference, University of California, Davis.

Bursey, C.R., S.R. Goldberg, and J.B. Bettaso. 2010. Persistence and Stability of the Component Helminth Community of the Foothill Yellow-Legged Frog, *Rana boylii* (Ranidae), from Humboldt County, California, 1964–1965, Versus 2004–2007. The American Midland Naturalist 163(2):476-482. https://doi.org/10.1674/0003-0031-163.2.476

Burton, C.A., T.M. Hoefen, G.S. Plumlee, K.L. Baumberger, A.R. Backlin, E. Gallegos, and R.N. Fisher. 2016. Trace Elements in Stormflow, Ash, and Burned Soil Following the 2009 Station Fire in Southern California. PLoS ONE 11(5):e0153372. DOI: 10.1371/journal.pone.0153372

Bury, R.B. 1972. The Effects of Diesel Fuel on a Stream Fauna. California Department of Fish and Game Bulletin 58:291-295.

Bury, R.B., and N.R. Sisk. 1997. Amphibians and Reptiles of the Cow Creek Watershed in the BLM-Roseburg District. Draft report submitted to BLM-Roseburg District and Oregon Department of Fish and Wildlife-Roseburg. Biological Resources Division, USGS, Corvallis, OR.

Butsic, V., and J.C. Brenner. 2016. Cannabis (*Cannabis sativa* or *C. indica*) Agriculture and the Environment: A Systematic, Spacially-explicit Survey and Potential Impacts. Environmental Research Letters 11(4):044023.

California Department of Fish and Wildlife [CDFW]. 2018a. Considerations for Conserving the Foothill Yellow-Legged Frog. California Department of Fish and Wildlife; 5/14/2018. http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=157562

California Department of Fish and Wildlife [CDFW]. 2018b. Green Diamond Resource Company Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-026-01. Northern Region, Eureka, CA.

California Department of Fish and Wildlife [CDFW]. 2018c. Humboldt Redwood Company Foothill Yellow-legged Frog Incidental Take Permit. California Endangered Species Act Incidental Take Permit No. 2081-2018-039-01. Northern Region, Eureka, CA.

California Department of Food and Agriculture [CDFA]. 2018. California Grape Acreage Report, 2017 Summary. https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Acreage/2018/201804grpacSUMMARY.pdf

California Department of Forestry and Fire Protection [CAL FIRE]. 2019. Top 20 Largest California Wildfires. http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf

California Department of Pesticide Regulation [CDPR]. 2018. The Top 100 Sites Used by Pounds of Active Ingredients Statewide in 2016 (All Pesticides Combined). https://www.cdpr.ca.gov/docs/pur/pur16rep/top_100_sites_lbs_2016.pdf

California Department of Water Resources [CDWR]. 2016. Drought and Water Year 2016: Hot and Dry Conditions Continue. 2016 California Drought Update.

California Natural Resources Agency [CNRA]. 2016. Safeguarding California: Implementation Action Plan. California Natural Resources Agency. http://resources.ca.gov/docs/climate/safeguarding/Safeguarding%20California-Implementation%20Action%20Plans.pdf

California Secretary of State [CSOS]. 2016. Proposition 64 Marijuana Legalization Initiative Statute, Analysis by the Legislative Analyst.

California Water Commission [CWC]. 2019. Proposition 1 Water Storage Investment Program: Funding the Public Benefits of Water Storage Projects. Website accessed April 5, 2019 at https://cwc.ca.gov/Water-Storage

Carah, J.K., J.K. Howard, S.E. Thompson, A.G. Short Gianotti, S.D. Bauer, S.M. Carlson, D.N. Dralle, M.W. Gabriel, L.L. Hulette, B.J. Johnson, C.A. Knight, S.J. Kupferberg, S.L. Martin, R.L. Naylor, and M.E. Power. 2015. High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization. BioScience 65(8):822-829. DOI: 10.1093/biosci/biv083

Case, M.J., J.J. Lawler, and J.A. Tomasevic. 2015. Relative Sensitivity to Climate Change of Species in Northwestern North America. Biological Conservation 187:127-133.

Catenazzi, A., and S.J. Kupferberg. 2013. The Importance of Thermal Conditions to Recruitment Success in Stream-Breeding Frog Populations Distributed Across a Productivity Gradient. Biological Conservation 168:40-48.

Catenazzi, A., and S.J. Kupferberg. 2017. Variation in Thermal Niche of a Declining River-breeding Frog: From Counter-Gradient Responses to Population Distribution Patterns. Freshwater Biology 62:1255-1265.

Catenazzi, A., and S.J. Kupferberg. 2018. Consequences of Dam-Altered Thermal Regimes for a Riverine Herbivore's Digestive Efficiency, Growth and Vulnerability to Predation. Freshwater Biology 63(9):1037-1048. DOI: 10.1111/fwb.13112

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent Changes Towards Earlier Springs: Early Signs of Climate Warming in Western North America? Watershed Management Council Networker (Spring):3-7.

Cayan, D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate Change Scenarios for the California Region. Climatic Change 87 (Supplement 1):21-42. DOI: 10.1007/s10584-007-9377-6

Climate Change Science Program [CCSP]. 2008. Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. *In* T.R. Karl, G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (Editors). Department of Commerce, NOAA's National Climate Data Center, Washington, DC.

Conlon, J.M., A. Sonnevend, M. Patel, C. Davidson, P.F. Nielsen, T. Pál, and L.A. Rollins-Smith. 2003. Isolation of Peptides of the Brevinin-1 Family with Potent Candidacidal Activity from the Skin Secretions of the Frog *Rana boylii*. The Journal of Peptide Research 62:207-213.

Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains. Science Advances 1(1):e1400082. DOI: 10.1126/sciadv.1400082

Cook, D.G., S. White, and P. White. 2012. *Rana boylii* (Foothill Yellow-legged Frog) Upland Movement. Herpetological Review 43(2):325-326.

Cordone, A.J., and D.W. Kelley. 1961. The Influence of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game 47(2):189-228.

Crayon, J.J. 1998. *Rana catesbeiana* (Bullfrog). Diet. Herpetological Review 29(4):232.

Davidson, C. 2004. Declining Downwind: Amphibian Population Declines in California and Historical Pesticide Use. Ecological Applications 14(6):1892-1902.

Davidson, C., H.B. Shaffer, and M.R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B, and Climate-Change Hypotheses for California Amphibian Declines. Conservation Biology 16(6):1588-1601.

Davidson, C., M.F. Benard, H.B. Shaffer, J.M. Parker, C. O'Leary, J.M. Conlon, and L.A. Rollins-Smith. 2007. Effects of Chytrid and Carbaryl Exposure on Survival, Growth and Skin Peptide Defenses in Foothill Yellow-legged Frogs. Environmental Science and Technology 41(5):1771-1776. DOI: 10.1021/es0611947

Dawson, T.P., S.T. Jackson, J.I. House, I.C. Prentice, and G.M. Mace. 2011. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science 332:53-58.

Dettinger, M., H. Alpert, J. Battles, J. Kusel, H. Safford, D. Fougeres, C. Knight, L. Miller, and S. Sawyer. 2018. Sierra Nevada Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004.

Dever, J.A. 2007. Fine-scale Genetic Structure in the Threatened Foothill Yellow-legged Frog (*Rana boylii*). Journal of Herpetology 41(1):168-173.

Dillingham, C.P., C.W. Koppl, J.E. Drennan, S.J. Kupferberg, A.J. Lind, C.S. Silver, T.V. Hopkins, K.D. Wiseman, and K.R. Marlow. 2018. *In Situ* Population Enhancement of an At-Risk Population of Foothill Yellow-legged Frogs, *Rana boylii*, in the North Fork Feather River, Butte County, California. Abstract of a paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 11-12 January 2018, Auburn, CA.

Doubledee, R.A., E.B. Muller, and R.M. Nisbet. 2003. Bullfrogs, Disturbance Regimes, and the Persistence of California Red-legged Frogs. Journal of Wildlife Management 67(2):424-438.

Drennan, J.E., K.A. Marlow, K.D. Wiseman, R.E. Jackman, I.A. Chan, and J.L. Lessard. 2015. *Rana boylii* Aging: A Growing Concern. Abstract of paper presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 8-10 January 2015, Malibu, CA.

Drost, C.A., and G.M. Fellers. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. Conservation Biology 10(2):414-425.

East Contra Costa County Habitat Conservancy [ECCCHC]. 2018. East Contra Costa County Habitat Conservation Plan/Natural Community Conservation Plan Annual Report 2017.

Ecoclub Amphibian Group, K.L. Pope, G.M. Wengert, J.E. Foley, D.T. Ashton, and R.G. Botzler. 2016. Citizen Scientists Monitor a Deadly Fungus Threatening Amphibian Communities in Northern Coastal California, USA. Journal of Wildlife Diseases 52(3):516-523.

El Dorado Irrigation District [EID]. 2007. Project 184 Foothill Yellow-legged Frog Monitoring Plan.

Electric Consumers Protection Act [ECPA]. 1986. 16 United States Code § 797, 803.

Eriksson A., F. Elías-Wolff, B. Mehlig, and A. Manica. 2014. The Emergence of the Rescue Effect from Explicit Within- and Between-Patch Dynamics in a Metapopulation. Proceedings of the Royal Society B 281:20133127. http://dx.doi.org/10.1098/rspb.2013.3127

Evenden, F.G., Jr. 1948. Food Habitats of *Triturus granulosus* in Western Oregon. Copeia 1948(3):219-220.

Fahrig, L., and G. Merriam. 1985. Habitat Patch Connectivity and Population Survival. Ecology 66(6):1762-1768.

Federal Energy Regulatory Commission [FERC]. 2007a. Order Issuing New License, Project No. 233-081.

Federal Energy Regulatory Commission [FERC]. 2007b. Relicensing Settlement Agreement for the Upper American River Project and Chili Bar Hydroelectric Project.

Federal Energy Regulatory Commission [FERC]. 2009a. Order Amending Forest Service 4(e) Condition 5A, Project No. 1962-187.

Federal Energy Regulatory Commission [FERC]. 2009b. Order Issuing New License, Project No. 2130-033.

Federal Energy Regulatory Commission [FERC]. 2014. Order Issuing New License, Project No. 2101-084.

Federal Energy Regulatory Commission [FERC]. 2018. Final Environmental Impact Statement. Lassen Lodge Hydroelectric Project. Project No. 12496-002.

Federal Energy Regulatory Commission [FERC]. 2019. Active Licenses. FERC eLibrary. Accessed March 10, 2019. https://www.ferc.gov/industries/hydropower/gen-info/licensing/active-licenses.xls

Fellers, G.M. 2005. *Rana boylii* Baird, 1854(b). Pp. 534-536 *In* M. Lannoo (Editor). Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.

Ferguson, E. 2019. Cultivating Cooperation: Pilot Study Around Headwaters of Mattole River Considers the Effect of Legal Cannabis Cultivators on Northern California Watersheds. Outdoor California 79(1):22-29.

Fidenci, P. 2006. *Rana boylii* (Foothill Yellow-legged Frog) Predation. Herpetological Review 37(2):208.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting Climate Change in California. Ecological Impacts on the Golden State. A report of the Union of Concerned Scientists, Cambridge, MA, and the Ecological Society of America, Washington, DC.

Fisher, R.N., and H.B. Shaffer. 1996. The Decline of Amphibians in California's Great Central Valley. Conservation Biology 10(5):1387-1397.

Fitch, H.S. 1936. Amphibians and Reptiles of the Rogue River Basin, Oregon. The American Midland Naturalist 17(3):634-652.

Fitch, H.S. 1938. *Rana boylii* in Oregon. Copeia 1938(3):148.

Fitch, H.S. 1941. The Feeding Habits of California Garter Snakes. California Fish and Game 27(2):1-32.

Florsheim, J.L., A. Chin, A.M. Kinoshita, and S. Nourbakhshbeidokhti. 2017. Effect of Storms During Drought on Post-Wildfire Recovery of Channel Sediment Dynamics and Habitat in the Southern California Chaparral, USA. Earth Surface Processes and Landforms 42(1):1482-1492. DOI: 10.1002/esp.4117.

Foe, C.G., and B. Croyle. 1998. Mercury Concentration and Loads from the Sacramento River and from Cache Creek to the Sacramento-San Joaquin Delta Estuary. Staff report, California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Fontenot, L.W., G.P. Noblet, and S.G. Platt. 1994. Rotenone Hazards to Amphibians and Reptiles. Herpetological Review 25(4):150-153, 156.

Fox, W. 1952. Notes on the Feeding Habits of Pacific Coast Garter Snakes. Herpetologica 8(1):4-8.

Fuller, D.D., and A.J. Lind. 1992. Implications of Fish Habitat Improvement Structures for Other Stream Vertebrates. Pp. 96-104 *In* Proceedings of the Symposium on Biodiversity of Northwestern California. R. Harris and D. Erman (Editors). Santa Rosa, CA.

Fuller, T.E., K.L. Pope, D.T. Ashton, and H.H. Welsh. 2011. Linking the Distribution of an Invasive Amphibian (*Rana catesbeiana*) to Habitat Conditions in a Managed River System in Northern California. Restoration Ecology 19(201):204-213. DOI: 10.1111/j.1526-100X.2010.00708.x

Furey, P.C., S.J. Kupferberg, and A.J. Lind. 2014. The Perils of Unpalatable Periphyton: *Didymosphenia* and Other Mucilaginous Stalked Diatoms as Food for Tadpoles. Diatom Research 29(3):267-280.

Gaos, A., and M. Bogan. 2001. A Direct Observation Survey of the Lower Rubicon River. California Department of Fish and Game, Rancho Cordova, CA.

Garcia and Associates [GANDA]. 2008. Identifying Microclimatic and Water Flow Triggers Associated with Breeding Activities of a Foothill Yellow-Legged Frog (*Rana boylii*) Population on the North Fork Feather River, California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-041.

Garcia and Associates [GANDA]. 2017. 2016 Surveys for Foothill Yellow-legged Frog El Dorado County, California for the El Dorado Hydroelectric Project (FERC No. 184) – Job 642-9. Prepared for El Dorado Irrigation District, San Francisco, CA.

Garcia and Associates [GANDA]. 2018. Draft Results of 2017 Surveys for Foothill Yellow-legged Frog (*Rana boylii*) on the Cresta and Poe Reaches of the North Fork Feather River – Job 708/145. Prepared for Pacific Gas and Electric Company, San Francisco, CA.

Geisseler, D., and W.R. Horwath. 2016. Grapevine Production in California. A collaboration between the California Department of Food and Agriculture; Fertilization Education and Research, Project; and University of California, Davis.
https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Grapevine_Production_CA.pdf

Gibbs, J.P., and A.R. Breisch. 2001. Climate Warming and Calling Phenology of Frogs Near Ithaca, New York, 1900-1999. Conservation Biology 15(4):1175-1178.

Gomulkiewicz, R., and R.D. Holt. 1995. When Does Evolution by Natural Selection Prevent Extinction? Evolution 49(1):201-207.

Gonsolin, T.T. 2010. Ecology of Foothill Yellow-legged Frogs in Upper Coyote Creek, Santa Clara County, CA. Master's Thesis. San Jose State University, San Jose, CA.

Grantham, T. E., A. M. Merenlender, and V. H. Resh. 2010. Climatic Influences and Anthropogenic Stressors: An Integrated Framework for Stream Flow Management in Mediterranean-climate California, U.S.A. Freshwater Biology 55(Supplement 1):188-204. DOI: 10.1111/j.1365-2427.2009.02379.x

Green, D.M. 1986a. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Karyological Evidence. Systematic Zoology 35(3):273-282.

Green, D.M. 1986b. Systematics and Evolution of Western North American Frogs Allied to *Rana aurora* and *Rana boylii*: Electrophoretic Evidence. Systematic Zoology 35(3):283-296.

Green Diamond Resource Company [GDRC]. 2018. Mad River Foothill Yellow-legged Frog Egg Mass Surveys Summary Humboldt County, California. Progress report to the California Department of Fish and Wildlife, Wildlife Branch-Nongame Wildlife Program, pursuant to the requirements of Scientific Collecting Permit Entity #6348.

Griffin, D., and K.J. Anchukaitis. 2014. How Unusual is the 2012-2014 California Drought? Geophysical Research Letters 41: 9017-9023. DOI: 10.1002/2014GL062433.

Grinnell, J., and T. I. Storer. 1924. Animal Life in the Yosemite: An Account of the Mammals, Birds, Reptiles, and Amphibians in a Cross-section of the Sierra Nevada. University of California Press, Berkeley, CA.

Grinnell, J., J. Dixon, and J.M. Linsdale. 1930. Vertebrate Natural History of a Section of Northern California Through the Lassen Peak Region. University of California Press, Berkeley, CA.

Haggarty, M. 2006. Habitat Differentiation and Resource Use Among Different Age Classes of Post Metamorphic *Rana boylii* on Red Bank Creek, Tehama County, California. Master's Thesis. Humboldt State University, Arcata, CA.

Harvey, B.C., and T.E. Lisle. 1998. Effects of Suction Dredging on Streams: A Review and an Evaluation Strategy. Fisheries 23(8):8-17.

Hayes, M.P., and M.R. Jennings. 1986. Decline of Ranid Frog Species in Western North America: Are Bullfrogs (*Rana catesbeiana*) Responsible? Journal of Herpetology 20(4):490-509.

Hayes, M.P., and M.R. Jennings. 1988. Habitat Correlates of Distribution of the California Red-legged Frog (*Rana aurora draytonii*) and the Foothill Yellow-Legged Frog (*Rana boylii*): Implications for Management. Pp. 144-158 *In* Management of Amphibians, Reptiles, and Small Mammals in North America, General Technical Report. RM-166 R.C. Szaro, K.E. Severson, and D.R. Patton (Technical Coordinators). USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hayes, M.P., C.A. Wheeler, A.J. Lind, G.A. Green, and D.C. Macfarlane (Technical Coordinators). 2016. Foothill Yellow-Legged Frog Conservation Assessment in California. Gen. Tech. Rep. PSW-GTR-248. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffle, and A. Vonk. 2003. Atrazine-induced Hermaphroditism at 0.1 ppb in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence. Environmental Health Perspectives 11(4):568-575.

Hayes, T.B., P. Case, S. Chui, D. Chung, C. Haeffele, K. Haston, M. Lee, V. P. Mai, Y. Marjuoa, J. Parker, and M. Tsui. 2006. Pesticide Mixtures, Endocrine Disruption, and Amphibian Declines: Are We Underestimating the Impact? Environmental Health Perspectives 114(Supplement 1):40-50.

Hemphill, D.V. 1952. The Vertebrate Fauna of the Boreal Areas of the Southern Yolla Bolly Mountains, California. PhD Dissertation. Oregon State University, Corvallis.

Hillis, D.M., and T.P. Wilcox. 2005. Phylogeny of the New World true frogs (*Rana*). Molecular Phylogenetics and Evolution 34:299-314.

Hoffmann, A.A., and C.M. Sgrò. 2011. Climate Change and Evolutionary Adaptation. Nature 470:479-485. https://www.nature.com/articles/nature09670

Hogan, S., and C. Zuber. 2012. North Fork American River 2012 Summary Report. California Department of Fish and Wildlife Heritage and Wild Trout Program, Rancho Cordova, CA.

Hopkins, G.R., S.S. French, and E.D. Brodie. 2013. Increased Frequency and Severity of Developmental Deformities in Rough-skinned Newt (*Taricha granulosa*) Embryos Exposed to Road Deicing Salts (NaCl & $MgCl_2$). Environmental Pollution 173:264-269. http://dx.doi.org/10.1016/j.envpol.2012.10.002

Hothem, R.L., A.M. Meckstroth, K.E. Wegner, M.R. Jennings, and J.J. Crayon. 2009. Diets of Three Species of Anurans from the Cache Creek Watershed, California, USA. Journal of Herpetology 43(2):275-283.

Hothem, R.L., M.R. Jennings, and J.J. Crayon. 2010. Mercury Contamination in Three Species of Anuran Amphibians from the Cache Creek Watershed, California, USA. Environmental Monitoring and Assessment 163:433-448. https://doi.org/10.1007/s10661-009-0847-3

Humboldt Redwoods Company [HRC]. 2015. Habitat Conservation Plan for the Properties of The Pacific Lumber Company, Scotia Pacific Holding Company, and Salmon Creek Corporation under the Ownership and Management of Humboldt Redwood Company, LLC, as of July 2008. Established February 1999, Revised 12 August 2015.

ICF International. 2012. Final Santa Clara Valley Habitat Plan. https://scv-habitatagency.org/178/Santa-Clara-Valley-Habitat-Plan

Jackman, R.E., J.E. Drennan, K.R. Marlow, and K.D. Wiseman. 2004. Some Effects of Spring and Summer Pulse Flows on River-breeding Foothill Yellow-legged Frogs (*Rana boylii*) along the North Fork Feather

River. Abstract of paper presented at the Cal-Neva and Humboldt Chapters of the American Fisheries Society Annual Meeting 23 April 2004, Redding, CA.

Jennings, M.R., and M.P. Hayes. 1985. Pre-1900 Overharvest of California Red-Legged Frogs (*Rana aurora draytonii*): The Inducement for Bullfrog (*Rana catesbeiana*) Introduction. Herpetologica 41(1):94-103.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Contract No. 8023. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA.

Jennings, M.R., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Coloration. Herpetological Review 36(4):438.

Jones & Stokes Associates. 2006. East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan.

Karraker, N.E., J.P. Gibbs, and J.R. Vonesh. 2008. Impacts of Road Deicing Salt on the Demography of Vernal Pool-breeding Amphibians. Ecological Applications 18(3):724-734.

Kats, L.B., and R.P. Ferrer. 2003. Alien Predators and Amphibian Declines: Review of Two Decades of Science and the Transition to Conservation. Diversity and Distributions 9(2):99-110.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streambank Management Implications…A review. Journal of Range Management 37(5):430-437.

Kauffman, J.B., W.C. Krueger, and M. Varva. 1983. Impacts of Cattle on Streambanks in Northeastern Oregon. Journal of Range Management 36(6):683-685.

Keeley, J.E. 2005. Fire History of the San Francisco East Bay Region and Implications for Landscape Patterns. International Journal of Wildland Fire 14:285-296.

Keeley, J.E., and A.D. Syphard. 2016. Climate Change and Future Fire Regimes: Examples from California. Geosciences 6(7):37. DOI: 10.3390/geosciences6030037

Kerby, J.L., and A. Sih. 2015. Effects of Carbaryl on Species Interactions of the Foothill Yellow Legged Frog (*Rana boylii*) and the Pacific Treefrog (*Pseudacris regilla*). Hydrobiologia 746(1):255-269. DOI: 10.1007/s10750-014-2137-5

Kiesecker, J.M. 2002. Synergism Between Trematode Infection and Pesticide Exposure: A Link to Amphibian Limb Deformities in Nature? PNAS 99(15):9900-9904. https://doi.org/10.1073/pnas.152098899

Kiesecker, J.M., and A.R. Blaustein. 1997. Influences of Egg Laying Behavior on Pathogenic Infection of Amphibian Eggs. Conservation Biology 11(1):214-220.

Knowles, N., M.D. Dettinger, and D.R. Cayan. 2006. Trends in Snowfall Versus Rainfall in the Western United States. Journal of Climate 19(18):4545-4559. https://doi.org/10.1175/JCLI3850.1

Kupferberg, S.J. 1996a. Hydrologic and Geomorphic Factors Affecting Conservation of a River-Breeding Frog (*Rana boylii*). Ecological Applications 6(4):1322-1344.

Kupferberg, S.J. 1996b. The Ecology of Native Tadpoles (*Rana boylii* and *Hyla regilla*) and the Impact of Invading Bullfrogs (*Rana catesbeiana*) in a Northern California River. PhD Dissertation. University of California, Berkeley.

Kupferberg, S.J. 1997a. Bullfrog (*Rana catesbeiana*) Invasion of a California River: The Role of Larval Competition. Ecology 78(6):1736-1751.

Kupferberg, S.J. 1997b. The Role of Larval Diet in Anuran Metamorphosis. American Zoology 37:146-159.

Kupferberg, S., and A. Catenazzi. 2019. Between Bedrock and a Hard Place: Riverine Frogs Navigate Tradeoffs of Pool Permanency and Disease Risk During Drought. Abstract prepared for the Joint Meeting of Ichthyologists and Herpetologists. 24-28 July 2019, Snowbird, UT.

Kupferberg, S.J., A. Catenazzi, K. Lunde, A. Lind, and W. Palen. 2009a. Parasitic Copepod (*Lernaea cyprinacea*) Outbreaks in Foothill Yellow-legged Frogs (*Rana boylii*) Linked to Unusually Warm Summers and Amphibian Malformations in Northern California. Copeia 2009(3):529-537.

Kupferberg, S.J., A. Catenazzi, and M.E. Power. 2011a. The Importance of Water Temperature and Algal Assemblage for Frog Conservation in Northern California Rivers with Hydroelectric Projects. Final Report to the California Energy Commission, PIER. CEC-500-2014-033.

Kupferberg, S.J., and P.C. Furey. 2015. An Independent Impact Analysis using Carnegie State Vehicular Recreation Area Habitat Monitoring System Data. Friends of Tesla Park Technical Memorandum. DOI: 10.13140/RG.2.1.4898.9207

Kupferberg, S.J., A. Lind, J. Mount, and S. Yarnell. 2009b. Pulsed Flow Effects on the Foothill Yellow-Legged Frog (*Rana boylii*): Integration of Empirical, Experimental, and Hydrodynamic Modeling Approaches. Final Report. California Energy Commission, PIER. CEC-500-2009-002.

Kupferberg, S.J, A.J. Lind, and W.J. Palen. 2009c. Pulsed Flow Effects on the Foothill Yellow-legged Frog (*Rana boylii*): Population Modeling. Final Report to the California Energy Commission, PIER. CEC-500-2009-002a.

Kupferberg, S.J., A.J. Lind, V. Thill, and S.M. Yarnell. 2011b. Water Velocity Tolerance in Tadpoles of the Foothill Yellow-legged Frog (*Rana boylii*): Swimming Performance, Growth, and Survival. Copeia 2011(1):141-152.

Kupferberg, S.J., W.J. Palen, A.J. Lind, S. Bobzien, A. Catenazzi, J. Drennan, and M.E. Power. 2012. Effects of Flow Regimes Altered by Dams on Survival, Population Declines, and Range-wide Losses of California River-Breeding Frogs. Conservation Biology 26(3):513-524.

Lambert, M.R., T. Tran, A. Kilian, T. Ezaz, and D.K. Skelly. 2019. Molecular Evidence for Sex Reversal in Wild populations of Green Frogs (*Rana clamitans*). PeerJ 7:e6449. DOI: 10.7717/peerj.6449

Lande, R., and S. Shannon. 1996. The Role of Genetic Variation in Adaptation and Population Persistence in a Changing Environment. Evolution 50(1):434-437.

Leidy, R.A., E. Gonsolin, and G.A. Leidy. 2009. Late-summer Aggregation of the Foothill Yellow-legged Frog (*Rana boylii*) in Central California. The Southwestern Naturalist 54(3):367-368.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, and J.N. Seiber. 1999. Summertime Transport of Current-Use Pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. Environmental Toxicology and Chemistry 18(12):2715-2722.

Lind, A.J. 2005. Reintroduction of a Declining Amphibian: Determining an Ecologically Feasible Approach for the Foothill Yellow-legged Frog (*Rana boylii*) Through Analysis of Decline Factors, Genetic Structure, and Habitat Associations. PhD Dissertation. University of California, Davis.

Lind, A.J., J.B. Bettaso, and S.M. Yarnell. 2003a. Natural History Notes: *Rana boylii* (Foothill Yellow-legged Frog) and *Rana catesbeiana* (Bullfrog). Reproductive behavior. Herpetological Review 34(3):234-235.

Lind, A.J., L. Conway, H. (Eddinger) Sanders, P. Strand, and T. Tharalson. 2003b. Distribution, Relative Abundance, and Habitat of Foothill Yellow-legged Frogs (*Rana boylii*) on National Forests in the Southern Sierra Nevada Mountains of California. Report to the FHR Program of Region 5 of the USDA Forest Service.

Lind, A.J., P.Q. Spinks, G.M. Fellers, and H.B. Shaffer. 2011. Rangewide Phylogeography and Landscape Genetics of the Western U.S. Endemic Frog *Rana boylii* (Ranidae): Implications for the Conservation of Frogs and Rivers. Conservation Genetics 12:269-284.

Lind, A.J., and H.H. Welsh, Jr. 1994. Ontogenetic Changes in Foraging Behaviour and Habitat Use by the Oregon Garter Snake, *Thamnophis atratus hydrophilus*. Animal Behaviour 48:1261-1273.

Lind, A.J., H.H. Welsh, Jr., and C.A. Wheeler. 2016. Foothill Yellow-legged Frog (*Rana boylii*) Oviposition Site Choice at Multiple Spatial Scales. Journal of Herpetology 50(2):263-270.

Lind, A.J., H.H. Welsh, Jr., and R.A. Wilson. 1996. The Effects of a Dam on Breeding Habitat and Egg Survival of the Foothill Yellow-Legged Frog (*Rana boylii*) in Northwestern California. Herpetological Review 27(2):62-67.

Little, E.E., and R.D. Calfee. 2000. The Effects of UVB Radiation on the Toxicity of Fire-Fighting Chemicals. Final Report. U.S. Geological Service, Columbia Environmental Research Center, Columbia, MO.

Loomis, R.B. 1965. The Yellow-legged Frog, *Rana boylei*, from the Sierra San Pedro Mártir, Baja California Norte, México. Herpetologica 21(1):78-80.

Lowe, J. 2009. Amphibian Chytrid (*Batrachochytrium dendrobatidis*) in Postmetamorphic *Rana boylii* in Inner Coast Ranges of Central California. Herpetological Review 40(2):180.

Macey, R.J., J.L. Strasburg, J.A. Brisson, V.T. Vredenburg, M. Jennings, and A. Larson. 2001. Molecular Phylogenetics of Western North American Frogs of the *Rana boylii* Species Group. Molecular Phylogenetics and Evolution 19(1):131-143.

MacTague, L., and P.T. Northen. 1993. Underwater Vocalization by the Foothill Yellow-Legged Frog (*Rana boylii*). Transactions of the Western Section of the Wildlife Society 29:1-7.

Mallakpour, I., M. Sadegh, and A. AghaKouchak. 2018. A New Normal for Streamflow in California in a Warming Climate: Wetter Wet Seasons and Drier Dry Seasons. Journal of Hydrology 567:203-211.

Mallery, M. 2010. Marijuana National Forest: Encroachment on California Public Lands for Cannabis Cultivation. Berkeley Undergrad Journal 23(2):1-50. http://escholarship.org/uc/item/7r10t66s#page-2

Marlow, C.B., and T.M. Pogacnik. 1985. Time of Grazing and Cattle-Induced Damage to Streambanks. Pp. 279-284 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Marlow, K.R., K.D. Wiseman, C.A. Wheeler, J.E. Drennan, and R.E. Jackman. 2016. Identification of Individual Foothill Yellow-legged Frogs (*Rana boylii*) using Chin Pattern Photographs: A Non-Invasive and Effective Method for Small Population Studies. Herpetological Review 47(2):193-198.

Martin, C. 1940. A New Snake and Two Frogs for Yosemite National Park. Yosemite Nature Notes 19(11):83-85.

Martin, P.L., R.E. Goodhue, and B.D. Wright. 2018. Introduction. Pp. 1-25 *In* California Agriculture: Dimensions and Issues. P.L. Martin, R.E. Goodhue, and B.D. Wright (Editors). Giannini Foundation Information Series 18-01, University of California.
https://s.giannini.ucop.edu/uploads/giannini_public/07/5c/075c8120-3705-4a79-ae74-130fdfe46c6b/introduction.pdf

McCartney-Melstad, E., M. Gidiş, and H.B. Shaffer. 2018. Population Genomic Data Reveal Extreme Geographic Subdivision and Novel Conservation Actions for the Declining Foothill Yellow-legged Frog. Heredity 121:112-125.

Megahan, W.F., J.G. King, and K.A. Seyedbagheri. 1995. Hydrologic and Erosional Responses of a Granitic Watershed to Helicopter Logging and Broadcast Burning. Forest Science 41(4):777-795.

Merenlender, A.M. 2000. Mapping Vineyard Expansion Provides Information on Agriculture and the Environment. California Agriculture 54(3):7-12.

Mierau, D.W., W.J. Trush, G.J. Rossi, J.K. Carah, M.O. Clifford, and J.K. Howard. 2017. Managing Diversions in Unregulated Streams using a Modified Percent-of-Flow Approach. Freshwater Biology 63:752-768. DOI: 10.1111/fwb.12985

Moyle, P.B. 1973. Effects of Introduced Bullfrogs, *Rana catesbeiana*, on the Native Frogs of the San Joaquin Valley, California. Copeia 1973(1):18-22.

Moyle, P.B., and P.J. Randall. 1998. Evaluating the Biotic Integrity of Watersheds in the Sierra Nevada, California. Conservation Biology 12(6):1318-1326.

Napa County. 2010. Napa County Voluntary Oak Woodlands Management Plan.

National Integrated Drought Information System [NIDIS]. 2019. Drought in California from 2000-2019. National Drought Mitigation Center, U.S. Department of Agriculture Federal Drought Assistance. Accessed 25 April 2019 at https://www.drought.gov/drought/states/california

National Marine Fisheries Service [NMFS]. 2012. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, CA.

National Marine Fisheries Service [NMFS]. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office, Sacramento, CA.

National Marine Fisheries Service [NMFS]. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, CA.

Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians & Reptiles of the Pacific Northwest. University Press of Idaho, Moscow, ID.

Off-Highway Motor Vehicle Recreation Commission [OHMVRC]. 2017. Off-Highway Motor Vehicle Recreation Commission Program Report, January 2017. http://ohv.parks.ca.gov/pages/1140/files/OHMVR-Commission-2017-Program_Report-FINAL-Mar2017_web.pdf

Office of Environmental Health Hazard Assessment [OEHAA], California Environmental Protection Agency. 2018. Indicators of Climate Change in California. https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

Olson, D.H., and R. Davis. 2009. Conservation Assessment for the Foothill Yellow-legged Frog (*Rana boylii*) in Oregon. USDA Forest Service Region 6 and USDI Bureau of Land Management Interagency Special Status Species Program.

Olson, E.O., J.D. Shedd, and T.N. Engstrom. 2016. A Field Inventory and Collections Summary of Herpetofauna from the Sutter Buttes, an "Inland Island" within California's Great Central Valley. Western North American Naturalist 76(3):352-366.

Pacific Gas and Electric [PG&E]. 2018. Pit 3, 4, and 5 Hydroelectric Project (FERC Project No. 233) Foothill Yellow-Legged Frog Monitoring 2017 Annual Report.

Padgett-Flohr, G.E., and R.L. Hopkins. 2009. *Batrachochytrium dendrobatidis*, a Novel Pathogen Approaching Endemism in Central California. Diseases of Aquatic Organisms 83:1-9.

Palstra, F.P., and D.E. Ruzzante. 2008. Genetic Estimates of Contemporary Effective Population Size: What Can They Tell Us about the Importance of Genetic Stochasticity for Wild Population Persistence? Molecular Ecology 17:3428-3447. DOI: 10.1111/j.1365-294X.2008.03842.x

Paoletti, D.J., D.H. Olson, and A.R. Blaustein. 2011. Responses of Foothill Yellow-legged Frog (*Rana boylii*) Larvae to an Introduced Predator. Copeia 2011(1):161-168.

Parks, S.A., C. Miller, J.T. Abatzoglou, L.M. Holsinger, M-A. Parisien, and S.Z. Dobrowski. 2016. How Will Climate Change Affect Wildland Fire Severity in the Western US? Environmental Research Letters 11:035002. DOI: 10.1088/1748-9326/11/3/035002

Parmesan, C., and G. Yohe. 2003. A Globally Coherent Fingerprint of Climate Change Impacts across Natural Systems. Nature 421(6918):37-42. DOI: 10.1038/nature01286

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs Call at a Higher Pitch in Traffic Noise. Ecology and Society 12(1):25. http://www.ecologyandsociety.org/vol14/iss1/art25/

Peek, R.A. ~~2011~~2010. Landscape Genetics of Foothill Yellow-legged Frogs (*Rana boylii*) in Regulated and Unregulated Rivers: Assessing Connectivity and Genetic Fragmentation. Master's Thesis. University of San Francisco, San Francisco, CA.

Peek, R.A. 2018. Population Genetics of a Sentinel Stream-breeding Frog (*Rana boylii*). PhD Dissertation. University of California, Davis.

Peek, R., and S. Kupferberg. 2016. Assessing the Need for Endangered Species Act Protection of the Foothill Yellow-legged Frog (*Rana boylii*): What do Breeding Censuses Indicate? Abstract of poster presented at the CA/NV Amphibian and Reptile Task Force Annual Meeting 7-8 January 2016, Davis, CA.

Pilliod, D.S., R.B. Bury, E.J. Hyde, C.A. Pearl, and P.S. Corn. 2003. Fire and Amphibians in North America. Forest Ecology and Management 178:163-181.

Placer County Water Agency [PCWA]. 2008. Final AQ 12 – Special-Status Amphibian and Aquatic Reptile Technical Study Report – 2007. Placer County Water Agency Middle Fork American River Project (FERC No. 2079), Auburn, CA.

Pounds, A., A.C.O.Q. Carnaval, and S. Corn. 2007. Climate Change, Biodiversity Loss, and Amphibian Declines. Pp. 19-20 *In* C. Gascon, J.P. Collins, R.D. Moore, D.R. Church, J.E. McKay, and J.R. Mendelson III (Editors). IUCN Amphibian Conservation Action Plan, Proceedings: IUCN/SSC Amphibian Conservation Summit 2005.

Powell, R., R. Conant, and J.T. Collins. 2016. Peterson Field Guide to Reptiles and Amphibians of Eastern and Central America, Fourth Edition.

Power, M.E., M.S. Parker, and W.E. Dietrich. 2008. Seasonal Reassembly of a River Food Web: Floods, Droughts, and Impacts of Fish. Ecological Monographs 78(2):263-282.

Prado, M. 2005. Rare Frogs Put at Risk by Visitors in West Marin. Marin Independent Journal. Newspaper article, May 09, 2005.

Public Policy Institute of California [PPIC]. 2018. Storing Water. https://www.ppic.org/publication/californias-water-storing-water/

Public Policy Institute of California [PPIC]. 2019. California's Future: Population. https://www.ppic.org/wp-content/uploads/californias-future-population-january-2019.pdf

Radeloff, V.C., D.P. Helmers, H.A. Kramer, M.H. Mockrin, P.M. Alexandre, A. Bar-Massada, V. Butsic, T.J. Hawbaker, S. Martinuzzi, A.D. Syphard, and S.I. Stewart. 2018. Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk. PNAS 115(13):3314-3319. https://doi.org/10.1073/pnas.1718850115

Railsback, S.F., B.C. Harvey, S.J. Kupferberg, M.M. Lang, S. McBain, and H.H. Welsh, Jr. 2016. Modeling Potential River Management Conflicts between Frogs and Salmonids. Canadian Journal of Fisheries and Aquatic Sciences 73:773-784.

Reeder, N.M.M., A.P. Pessier, and V.T. Vredenburg. 2012. A Reservoir Species for the Emerging Amphibian Pathogen *Batrachochytrium dendrobatidis* Thrives in a Landscape Decimated by Disease. PLoS ONE 7(3):e33567. https://doi.org/10.1371/journal.pone.0033567

Riegel, J.A. 1959. The Systematics and Distribution of Crayfishes in California. California Fish and Game 45:29-50.

Relyea, R.A. 2005. The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Ecological Applications 15(2):618-627.

Relyea, R.A., and N. Diecks. 2008. An Unforeseen Chain of Events: Lethal Effects of Pesticides on Frogs at Sublethal Concentrations. Ecological Applications 18(7):1728-1742.

Rombough, C. 2006. Winter Habitat Use by Juvenile Foothill Yellow-legged Frogs (*Rana boylii*): The Importance of Seeps. *In* Abstracts from the 2006 Annual Meetings of the Society for Northwestern Vertebrate Biology and the Washington Chapter of the Wildlife Society. Northwest Naturalist 87(2):159.

Rombough, C.J., J. Chastain, A.M. Schwab, and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(4):438-439.

Rombough, C.J., and M.P. Hayes. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation: Eggs and Hatchlings. Herpetological Review 36(2):163-164.

Rombough, C.J., and M.P. Hayes. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Reproduction. Herpetological Review 38(1):70-71.

Russell, K.R., D.H. Van Lear, and D.C. Guynn, Jr. 1999. Prescribed Fire Effects on Herpetofauna: Review and Management Implications. Wildlife Society Bulletin 27(2):374-384.

San Joaquin Council of Governments, Inc. [SJCOG 2018]. San Joaquin County Multi-Species Habitat Conservation and Open Space Plan 2018 Annual Report.

San Joaquin County. 2000. San Joaquin County Multi-Species Habitat Conservation Plan and Open Space Plan.

Santa Clara Valley Habitat Agency [SCVHA]. 2019. Santa Clara Valley Habitat Plan 4th Annual Report FY2017-2018.

Scheele, B.C., F. Pasmans, L.F. Skerratt, L. Berger, A. Martel, W. Beukema, A.A. Acevedo, P.A. Burrows, T. Carvalhos, A. Catenazzi, I. De la Riva, M.C. Fisher, S.V. Flechas, C.N. Foster, P. Frías-Álvarez, T.W.J. Garner, B. Gratwicke, J.M. Guayasamin, M. Hirschfeld, J.E. Kolby, T.A. Kosch, E. La Marca, D.B. Lindenmayer, K.R. Lips, A.V. Longo, R. Maneyro, C.A. McDonald, J. Mendelson III, P. Palacios-Rodriguez, G. Parra-Olea, C.L. Richards-Zawacki, M-O. Rödel, S.M. Rovito, C. Soto-Azat, L.F. Toledo, J. Voyles, C. Weldon, S.M. Whitfield, M. Wilkinson, K.R. Zamudio, and S. Canessa. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. Science 363(6434):1459-1463. DOI: 10.1126/science.aav0379

Siekert, R.E., Q.D. Skinner, M.A. Smith, J.L. Dodd, and J.D. Rogers. 1985. Channel Response of an Ephemeral Stream in Wyoming to Selected Grazing Treatments. Pp. 276-278 *In* R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Folliott, and R.H. Hamre (Technical Coordinators). Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120.

Silver, C.S. 2017. Population-level Variation in Vocalizations of *Rana boylii*, the Foothill Yellow-legged Frog. Master's Thesis. California State University, Chico, Chico, CA.

Snover, M.L., and M.J. Adams. 2016. Herpetological Monitoring and Assessment on the Trinity River, Trinity County, California-Final Report: U.S. Geological Survey Open-File Report 2016-1089. http://dx.doi.org/10.3133/ofr20161089

Sparling, D.W., and G.M. Fellers. 2007. Comparative Toxicity of Chlorpyrifos, Diazinon, Malathion and Their Oxon Derivatives to *Rana boylii*. Environmental Pollution 147:535-539.

Sparling, D.W., and G.M. Fellers. 2009. Toxicity of Two Insecticides to California, USA, Anurans and Its Relevance to Declining Amphibian Populations. Environmental Toxicology and Chemistry 28(8):1696-1703.

Sparling, D.W., G.M. Fellers, and L.L. McConnell. 2001. Pesticides and Amphibian Declines in California, USA. Environmental Toxicology and Chemistry 20(7):1591-1595.

Spencer, C.N., and F.R. Hauer. 1991. Phosphorus and Nitrogen Dynamics in Streams During a Wildfire. Journal of the North American Benthological Society 10(1):24-30.

Spring Rivers Ecological Sciences. 2003. Foothill Yellow-legged Frog (*Rana boylii*) Studies in 2002 for Pacific Gas and Electric Company's Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233). Pacific Gas and Electric Company, Technical and Ecological Services, San Ramon, CA.

State Board of Forestry and Fire Protection [SBFFP]. 2018. 2018 Strategic Fire Plan for California. Accessed March 1, 2019 at: http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf1614.pdf

State Water Resources Control Board [SWRCB]. 2017. Water Quality Certification for the Pacific Gas and Electric Company Poe Hydroelectric Project, Federal Energy Regulatory Commission Project No. 2107.

State Water Resources Control Board [SWRCB]. 2018. Water Quality Certification for the South Feather Water and Power Agency South Feather Power Project, Federal Energy Regulatory Commission Project No. 2088.

State Water Resources Control Board [SWRCB]. 2019. February 2019 Executive Director's Report. Accessed February 18, 2019 at: https://www.waterboards.ca.gov/board_info/exec_dir_rpts/2019/ed_rpt_021119.pdf

Stebbins, R.C. 2003. Peterson Filed Guides Western Reptiles and Amphibians. Third Edition. Houghton Mifflin Company, Boston, MA.

Stebbins, R.C., and S.M. McGinnis. 2012. Field Guide to Amphibians and Reptiles of California. Revised Edition. University of California Press, Berkeley, CA.

Stephens, S.L., N. Burrows, A. Buyantuyev, R.W. Gray, R.E. Keane, R. Kubian, S. Liu, F. Seijo, L. Shu, K.G. Tolhurst, and J.W. van Wagtendonk. 2014. Temperate and Boreal Forest Mega-Fires: Characteristics and Challenges. Frontiers in Ecology and the Environment 12(2):115-122.

Stephens, S.L, J.D. McIver, R.E.J. Boerner, C.J. Fettig, J.B. Fontaine, B.R. Hartsough, P.I. Kennedy, and D.W. Schwilk. 2012. The Effects of Forest Fuel-Reduction Treatments in the United States. BioScience 62(6):549-560.

Stewart, I.T. 2009. Changes in Snowpack and Snowmelt Runoff for Key Mountain Regions. Hydrological Processes 23:78-94. DOI: 10.1002/hyp.7128

Stillwater Sciences. 2012. Analysis of Long-term River Regulation Effects on Genetic Connectivity of Foothill Yellow-legged Frogs (*Rana boylii*) in the Alameda Creek Watershed. Final Report. Prepared by Stillwater Sciences, Berkeley, CA for SFPUC, San Francisco, CA.

Stopper, G.F., L. Hecker, R.A. Franssen, and S.K. Sessions. 2002. How Trematodes Cause Limb Deformities in Amphibians. Journal of Experimental Zoology Part B (Molecular and Developmental Evolution) 294:252-263.

Storer, T.I. 1923. Coastal Range of Yellow-legged Frog in California. Copeia 114:8.

Storer, T.I. 1925. A Synopsis of the Amphibia of California. University of California Publication Zoology 27:1-342.

Sweet, S.S. 1983. Mechanics of a Natural Extinction Event: *Rana boylii* in Southern California. Abstract of paper presented at the Joint Annual Meeting of the Herpetologists' League and Society for the Study of Amphibians and Reptiles 7-12 August 1983, Salt Lake City, UT.

Syphard, A.D., V.C. Radeloff, T.J. Hawbaker, and S.I. Stewart. 2009. Conservation Threats Due to Human-Caused Increases in Fire Frequency in Mediterranean-Climate Ecosystems. Conservation Biology 23(3):758–769. DOI: 10.1111/j.1523-1739.2009.01223.x

Syphard, A.D., V.C. Radeloff, J.E. Keeley, T.J. Hawbaker, M.K. Clayton, S.I. Stewart, and R.B. Hammer. 2007. Human Influence on California Fire Regimes. Ecological Applications 17(5):1388-1402.

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos 68(3):571-573.

Thompson, C., R. Sweitzer, M. Gabriel, K. Purcell, R. Barrett, and R. Poppenga. 2014. Impacts of Rodenticide and Insecticide Toxicants from Marijuana Cultivation Sites on Fisher Survival Rates in the Sierra National Forest, California. Conservation Letters 7(2):91-102.

Thomson, R.C., A.N. Wright, and H.B. Shaffer. 2016. California Amphibian and Reptile Species of Special Concern. University of California Press, Berkeley, CA.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

Tracey, J.A., C.J. Rochester, S.A. Hathaway, K.L. Preston, A.D. Syphard, A.G. Vandergast, J.E. Diffendorfer, J. Franklin, J.B. MacKenzie, T.A. Oberbauer, S. Tremor, C.S. Winchell, and R.N. Fisher. 2018. Prioritizing Conserved Areas Threatened by Wildfire and Fragmentation for Monitoring and Management. PLoS ONE 13(9):e0200203. https://doi.org/10.1371/journal.pone.0200203

Troïanowski, M., N. Mondy, A. Dumet, C. Arcajo, and T. Lengagne. 2017. Effects of Traffic Noise on Tree Frog Stress Levels, Immunity, and Color Signaling. Conservation Biology 31(5):1132-1140.

Twitty, V.C., D. Grant, and O. Anderson. 1967. Amphibian Orientation: An Unexpected Observation. Science 155(3760):352-353.

Unrine, J.M., C.H. Jagoe, W.A. Hopkins, and H.A. Brant. 2004. Adverse Effects of Ecologically Relevant Dietary Mercury Exposure in Southern Leopard Frog (*Rana sphenocephala*) Larvae. Environmental Toxicology and Chemistry 23(12):2964-2970.

U.S. Fish and Wildlife Service [USFWS]. 1998. Recovery Plan for the Shasta Crayfish (*Pacifastacus fortis*). U.S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service [USFWS]. 2015. Endangered and Threatened Wildlife and Plants; 90-Day Findings on 31 Petitions. Federal Register 80(126):37568-37579.

U.S. Fish and Wildlife Service [USFWS] and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report. U.S. Fish and Wildlife Service, Arcata, CA.

U.S. Forest Service [USFS]. 2004. Sierra Nevada Forest Plan Amendment. Final Supplemental Environmental Impact Statement, Record of Decision.

U.S. Forest Service [USFS] and Bureau of Land Management [BLM]. 1994. Standards and guidelines for management of habitat for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl.

Van Wagner, T.J. 1996. Selected Life-History and Ecological Aspects of a Population of Foothill Yellow-legged Frogs (*Rana boylii*) from Clear Creek, Nevada County, California. Master's Thesis. California State University Chico, Chico, CA.

Volpe, R.J., III, R. Green, D. Heien, and R. Howitt. 2010. Wine-Grape Production Trends Reflect Evolving Consumer Demand over 30 Years. California Agriculture 64(1):42-46.

Wang, I.J., J.C. Brenner, and V. Bustic. 2017. Cannabis, an Emerging Agricultural Crop, Leads to Deforestation and Fragmentation. Frontiers in Ecology and the Environment 15(9):495-501. DOI: 10.1002/fee.1634

Warren, D.L., A.N. Wright, S.N. Seifert, and H.B. Shaffer. 2014. Incorporating Model Complexity and Spatial Sampling Bias into Ecological Niche Models of Climate Change Risks Faced by 90 California Vertebrate Species of Concern. Diversity and Distributions 20:334-343. DOI: 10.1111/ddi.12160

Welsh, H.H., Jr., and G.R. Hodgson. 2011. Spatial Relationships in a Dendritic Network: The Herpetofaunal Metacommunity of the Mattole River Catchment of Northwest California. Ecography 34:49-66. DOI: 10.1111/j.1600-0587.2010.06123.x

Welsh, H.H., Jr., G.R. Hodgson, and A.J. Lind. 2005. Ecography of the Herpetofauna of a Northern California Watershed: Linking Species Patterson to Landscape Processes. Ecography 23:521-536.

Welsh, H.H., Jr., and L.M. Ollivier. 1998. Stream Amphibians as Indicators of Ecosystem Stress: A Case Study from California's Redwoods. Ecological Applications 8(4):1118-1132.

Werschkul, D.F., and M.T. Christensen. 1977. Differential Predation by *Lepomis macrochirus* on the Eggs and Tadpoles of *Rana*. Herpetologica 33(2):237-241.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Science 313(5789):940-943. DOI: 10.1126/science.1128834

Wheeler, C.A., J.B. Bettaso, D.T. Ashton and H.H. Welsh, Jr. 2014. Effects of Water Temperature on Breeding Phenology, Growth, and Metamorphosis of Foothill Yellow-legged Frogs (*Rana boylii*): A Case Study of the Regulated Mainstem and Unregulated Tributaries of California's Trinity River. River Research and Applications 31:1276-1286. DOI: 10.1002/rra.2820

Wheeler, C.A., J.M. Garwood, and H.H. Welsh, Jr. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Physiological Skin Color Transformation. Herpetological Review 36(2):164-165.

Wheeler, C.A., A.J. Lind, H.H. Welsh, Jr., and A.K. Cummings. 2018. Factors that Influence the Timing of Calling and Oviposition of a Lotic Frog in Northwestern California. Journal of Herpetology 52(3):289-298.

Wheeler, C.A., and H.H. Welsh, Jr. 2008. Mating Strategy and Breeding Patterns of the Foothill Yellow-legged Frog (*Rana boylii*). Herpetological Conservation and Biology 3(2):128-142.

Wheeler, C.A., H.H. Welsh, Jr., and T. Roelofs. 2006. Oviposition Site Selection, Movement, and Spatial Ecology of the Foothill Yellow-legged Frog (*Rana boylii*). Final Report to the California Department of Fish and Game Contract No. P0385106, Sacramento, CA.

Williams, A.P., R. Seager, J.T. Abatzoglou, B.I. Cook, J.E. Smerdon, and E.R. Cook. 2015. Contribution of Anthropogenic Warming to California Drought During 2012–2014. Geophysical Research Letters 42:6819-6828. DOI: 10.1002/2015GL064924

Williams S.E., L.P. Shoo, J.L. Isaac, A.A. Hoffmann, and G. Langham. 2008. Towards an Integrated Framework for Assessing the Vulnerability of Species to Climate Change. PLoS Biol 6(12):e325. DOI: 10.1371/journal.pbio.0060325

Wiseman, K.D., and J. Bettaso. 2007. *Rana boylii* (Foothill Yellow-legged Frog). Cannibalism and Predation. Herpetological Review 38(2):193.

Wiseman, K.D., K.R. Marlow, R.E. Jackman, and J.E. Drennan. 2005. *Rana boylii* (Foothill Yellow-legged Frog). Predation. Herpetological Review 36(2):162-163.

Wright, A.N., R.J. Hijmans, M.W. Schwartz, and H.B. Shaffer. 2013. California Amphibian and Reptile Species of Future Concern: Conservation and Climate Change. Final Report to the California Department of Fish and Wildlife. Contract No. P0685904, Sacramento, CA.

Yap, T.A., M.S. Koo, R.F. Ambrose, and V.T. Vredenburg. 2018. Introduced Bullfrog Facilitates Pathogen Invasion in the Western United States. PLoS ONE 13(4):e0188384. https://doi.org/10.1371/journal.pone.0188384

Yarnell, S.M. 2005. Spatial Heterogeneity of *Rana boylii* Habitat: Physical Properties, Quantification and Ecological Meaningfulness. PhD Dissertation. University of California, Davis.

Yarnell, S.M., J.H. Viers, and J.F. Mount. 2010. Ecology and Management of the Spring Snowmelt Recession. Bioscience 60(2):114-127.

Yoon, J-H., S-Y.S. Wang, R.R. Gillies, B. Kravitz, L. Hipps, and P.J. Rasch. 2015. Increasing Water Cycle Extremes in California and in Relation to ENSO Cycle under Global Warming. Nature Communications 6:8657. DOI: 10.1038/ncomms9657

Young, C.A., M. Escobar, M. Fernandes, B. Joyce, M. Kiparsky, J.F. Mount, V. Mehta, J.H. Viers, and D. Yates. 2009. Modeling the Hydrology of California's Sierra Nevada for Sub-Watershed Scale Adaptation to Climate Change. Journal of American Water Resources Association 45:1409-1423.

Zhang, H., C. Cai, W. Fang, J. Wang, Y. Zhang, J. Liu, and X. Jia. 2013. Oxidative Damage and Apoptosis Induced by Microcystin-LR in the Liver of *Rana nigromaculata* in Vivo. Aquatic Toxicology 140-141:11-18.

Zillioux, E.J., D.B. Porcella, and J.M. Benoit. 1993. Mercury Cycling and Effects in Freshwater Wetland Ecosystems. Environmental Toxicology and Chemistry 12:2245-2264.

Zweifel, R.G. 1955. Ecology, Distribution, and Systematics of Frogs of the *Rana boylei* Group. University of California Publications in Zoology 54(4):207-292.

Zweifel, R.G. 1968. *Rana boylii* Baird, Foothill Yellow-legged Frog. Catalogue of American Amphibians and Reptiles. Pp. 71.1-71.2.

Personal Communications

Alvarez, J. 2017. The Wildlife Project. Email to the Department.

Alvarez, J. 2018. The Wildlife Project. Letter to Tom Eakin, Peter Michael Winery, provided to the Department.

Anderson, D.G. 2017. Redwood National Park. Foothill Yellow-legged Frog (*Rana boylii*) Survey of Redwood Creek on August 28, 2017, Mainstem Redwood Creek, Redwood National Park, Humboldt County, California.

Ashton, D. 2017. U.S. Geological Survey. Email response to Department solicitation for information.

Blanchard, K. 2018. California Department of Fish and Wildlife. Email response to Department solicitation for information.

Bourque, R. 2018. California Department of Fish and Wildlife. Email.

Bourque, R. 2019. California Department of Fish and Wildlife. Internal review comments.

Chinnichi, S. 2017. Humboldt Redwood Company. Email response to the Department solicitation for information.

Grefsrud, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Hamm, K. 2017. Green Diamond Resource Company. Email response to the Department solicitation for information.

Kundargi, K., 2014. California Department of Fish and Wildlife. Internal memo.

Kupferberg, S. 2018. UC Berkeley. Spreadsheet of Eel River egg mass survey results.

Kupferberg, S. 2019. UC Berkeley. Spreadsheet of breeding censuses and clutch density plots by river.

Kupferberg, S., and A. Lind. 2017. UC Berkeley and U.S. Forest Service. Draft recommendation for best management practices to the Department's North Central Region.

Kupferberg, S., and R. Peek. 2018. UC Davis and UC Berkeley. Email to the Department.

Kupferberg, S., R. Peek, and A. Catenazzi. 2015. UC Berkeley, UC Davis, and Southern Illinois University Carbondale. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., and M. Power. 2015. UC Berkeley. Public Comments to the USFWS's Solicitation for Information on the Foothill Yellow-legged Frog's Status, Docket # FWS-R8-ES-2015-0050.

Kupferberg, S., M. van Hattem, and W. Stokes. 2017. UC Berkeley and California Department of Fish and Wildlife. Email about lower flows in the South Fork Eel River and upstream cannabis.

Rose, T. 2014. Wildlife Photographer. Photographs of river otters consuming Foothill Yellow-legged Frogs on the Eel River.

Smith, J. 2015. San Jose State University. Frog and Turtle Studies on Upper Coyote Creek for (2010-2015; cumulative report).

Smith, J. 2016. San Jose State University. Upper Coyote Creek Stream Survey Report – 20 April 2016.

Smith, J. 2017. San Jose State University. Upper Llagas Creek Fish Resources in Response to the Recent Drought, Fire, and Extreme Wet Winter, 8 October 2017.

Sweet, S. 2017. University of California Santa Barbara. Email to the Department.

van Hattem, M. 2018. California Department of Fish and Wildlife. Telephone call.

van Hattem, M. 2019. California Department of Fish and Wildlife. Internal review comments.

Weiss, K. 2018. California Department of Fish and Wildlife. Email.

Geographic Information System Data Sources

Amphibian and Reptile Species of Special Concern [ARSSC]. 2012. Museum Dataset.

Biological Information Observation System [BIOS]. Aquatic Organisms [ds193]; Aquatic Ecotoxicology - Whiskeytown NRA 2002-2003 [ds199]; North American Herpetological Education and Research Project (HERP) - Gov [ds1127]; and Electric Power Plants - California Energy Commission [ds2650].

California Department of Fish and Wildlife [CDFW]. Various Unpublished Foothill Yellow-legged Frog Observations from 2009 through 2018.

California Department of Food and Agriculture [CDFA]. Temporary Licenses Issued for Commercial Cannabis Cultivation, January 2019 version.

California Department of Forestry [CAL FIRE]. 2017 Fire Perimeters and 2018 Supplement.

California Department of Water Resources [DWR]. 2000. Dams under the Jurisdiction of the Division of Safety and Dams.

California Military Department [CMD]. Camp Roberts Boundary.

California Natural Diversity Database [CNDDB]. February 2019 version.

California Protected Areas Database [CPAD]. Public Lands, 2017 version.

California Wildlife Habitat Relationships [CWHR]. 2014 Range Map Modified to Include the Sutter Buttes.

Electronic Water Rights Information Management System [eWRIMS]. Points of Diversion - State Water Resources Control Board, 2019 version.

Facility Registry Service [FRS]. Power Plants Operated by the Army Corps of Engineers – U.S. Environmental Protection Agency Facility Registry Service, 2014 version.

Humboldt Redwood Company [HRC]. Incidental Foothill Yellow-legged Frog Observations from 1995 to 2018.

Mendocino Redwoods Company [MRC]. Foothill Yellow-legged Frog Egg Mass Survey Results from 2017 and 2018.

National Hydrography Dataset [NHD]. Watershed Boundary Dataset, 2018 version.

PRISM Climate Group [PRISM]. Annual Average Precipitation for 2012 through 2016; and the 30 Year Average from 1980-2010.

Thorne, J.H., R.M. Boynton, A.J. Holguin, J.A.E. Stewart, and J. Bjorkman. 2016. A Climate Change Vulnerability Assessment of California's Terrestrial Vegetation. California Department of Fish and Wildlife, Sacramento, CA.

U.S. Bureau of Land Management [BLM]. Tribal Lands - Bureau of Indian Affairs Surface Management, 2014 version.

U.S. Department of Defense [DOD]. Military Lands Boundaries in California.

California Fish and Game Commission

Staff Report on Staff Time Allocation and Activities

September 30, 2019

Commission staff time is a tangible and invaluable asset. Especially since the Commission's staff is so small, where and how staff members spend their time is important. This report identifies where Commission staff allocated time to general activity categories (see table; sample tasks for each general category begin on the next page) and to specific activities during August and September 2019.

The general allocation table summarizes time across all staff classifications, though some classifications require a greater emphasis on certain task categories than others. For example, advisors can spend 30% or more of their time on special projects due to committee project assignments, while regulatory analysts spend up to 70% of their time on regulatory program tasks. Of note during this reporting period, staff increased its allocation under special projects and administration. For special projects, this represents staff time for specific staff to work on the California Coastal Fishing Communities Project. An increase in the administration category is the result of recruitment and hiring actions for two vacant positions.

General Allocation

Task Category	August Staff Time	September Staff Time
Regulatory Program	15%	15%
Non-Regulatory Program	3%	3%
Commission/Committee Meetings	22%	20%
Legal Matters	3%	5%
External Affairs	5%	7%
Special Projects	8%	11%
Administration	20%	23%
Leave Time	19%	14%
Unfilled Positions	6%	6%
Total Staff Time[1]	101%	104%

[1] *Total staff time is greater than 100% due to overtime*

Activities for August 2019

- Prepared for and conducted two publicly noticed meetings (August 7-8 Fish and Game Commission, August 8 Water Resiliency Listening Session)
- Began preparations for two publicly noticed meetings (September 3 Commission teleconference, September 10 Wildlife Resources Committee)

- Prepared for and conducted bullfrog environmental/animal welfare stakeholder meeting
- Completed service-based budgeting data collection and participated in gap analysis review
- Conducted executive director recruitment
- Conducted joint regulations coordination meeting with California Department of Fish and Wildlife (DFW) Regulations Unit
- Participated in chronic wasting disease task force meeting
- Participated in MPA Statewide Leadership Team *Other Uses Subgroup* meeting
- Participated in DFW Regulations Unit Quarterly Coordination meeting

Activities for September 2019

- Finalized preparations for and conducted two publicly noticed meetings (September 3 Commission teleconference, September 10 Wildlife Resources Committee)
- Began preparations for one two publicly noticed meetings (October 8 Tribal Committee, October 9-10 Commission)
- Prepared for and conducted public outreach activities at 2019 California Native American Day
- Conducted interviews and completed hiring process for seasonal clerk and completed hiring process for executive director
- Prepared for and conducted Tribal Committee workgroup meeting
- Prepared for and conducted stakeholder discussion about draft delta fisheries management policy and potential revisions to Commission Striped Bass Policy
- Prepared for and conducted bullfrog environmental/animal welfare stakeholder meeting
- Participated in the California Natural Resources Agency Directors Convening
- Participated in climate-ready fisheries training
- Participated in fishing research with California Collaborative Fisheries Research Program
- Participated in Red Abalone Fishery Management Plan Project Team and Administrative Team meetings
- Participated in MPA Statewide Leadership Team *Other Uses Subgroup* meetings
- Participated in conference on the ocean's role in sustainable food production
- Participated in DFW Joint Leadership Team meeting

General Allocation Categories with Sample Tasks

Regulatory Program

- Coordination meetings with DFW to develop timetables and notices
- Prepare and file notices, re-notices, and initial/final statements of reasons
- Prepare administrative records
- Track and respond to public comments
- Consult, research and respond to inquiries from the Office of Administrative Law

Non-Regulatory Program

- DFW partnership, including joint development of management plans and concepts
- Process and analyze non-regulatory requests
- Develop, review and amend Commission policies
- Research and review adaptive management practices
- Review and process California Endangered Species Act petitions

Commission/Committee Meetings and Support

- Research and compile subject-specific information
- Review and develop policies
- Develop and distribute meeting agendas and materials
- Agenda and debrief meetings
- Prepare meeting summaries, audio files and voting records
- Research and secure meeting venues
- Develop and distribute after-meeting memos/letters
- Make travel arrangements for staff and commissioners
- Conduct onsite meeting management
- Process submitted meeting materials
- Provide commissioner support (expense claims, office hours, etc.)
- Process and analyze regulatory petitions

Legal Matters

- Public Records Act requests
- Process appeals and accusations
- Process requests for permit transfers
- Process kelp and state water bottom leases
- Litigation
- Prepare administrative records

External Affairs

- Engage and educate legislators, monitor legislation
- Maintain state, federal and tribal government relations
- Correspondence
- Respond to public inquiries
- Website maintenance

Special Projects

- Coastal Fishing Communities
- Fisheries Bycatch Workgroup
- Streamline routine regulatory actions
- Strategic planning
- Aquaculture best management practices
- Website transition
- Service Based Budgeting Initiative

Administration

- Staff training and development
- Purchases and payments
- Contract management
- Personnel management
- Budget development and tracking
- Health and safety oversight
- Internal processes and procedures
- Document archival

Leave Time

- Holidays
- Sick leave
- Vacation or annual leave
- Jury duty
- Bereavement

Unfilled

- Deputy executive director
- Seasonal clerk

Department of Fish & Wildlife Legislative Report

September 2019

(as of September 30, 2019 at 9:00 a.m.)

AB 44 (**Friedman** D) **Fur products: prohibition.**
Introduced: 12/3/2018
Last Amend: 9/6/2019
Status: 9/20/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/20/2019-A. ENROLLED
Summary: Would make it unlawful to sell, offer for sale, display for sale, trade, or otherwise distribute for monetary or nonmonetary consideration a fur product, as defined, in the state. The bill would also make it unlawful to manufacture a fur product in the state for sale. The bill would exempt from these prohibitions used fur products, as defined, fur products used for specified purposes, and any activity expressly authorized by federal law. The bill would require a person that sells or trades any fur product exempt from this prohibition to maintain records of each sale or trade of an exempt fur product for at least one year, except as provided.

AB 202 (**Mathis** R) **Endangered species: conservation: California State Safe Harbor Agreement Program Act.**
Introduced: 1/14/2019
Last Amend: 2/26/2019
Status: 7/10/2019-Failed Deadline pursuant to Rule 61(a)(10). (Last location was N.R. & W. on 4/24/2019)(May be acted upon Jan 2020)
Location: 7/10/2019-S. 2 YEAR
Summary: Would delete the January 1, 2020, repeal date of the California State Safe Harbor Agreement Program Act, thereby extending the operation of the act indefinitely. Because submission of false, inaccurate, or misleading information on an application for a state safe harbor agreement under the act would be a crime, this bill would extend the application of a crime, thus imposing a state-mandated local program.

AB 231 (**Mathis** R) **California Environmental Quality Act: exemption: recycled water.**
Introduced: 1/17/2019
Status: 5/9/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was NAT. RES. on 2/7/2019)(May be acted upon Jan 2020)(Recorded 4/26/2019)
Location: 2/7/2019-A. 2 YEAR
Summary: Would exempt from CEQA a project to construct or expand a recycled water pipeline for the purpose of mitigating drought conditions for which a state of emergency was proclaimed by the Governor if the project meets specified criteria. Because a lead agency would be required to determine if a project qualifies for this exemption, this bill would impose a state-mandated local program. The bill would also exempt from CEQA the development and approval of building standards by state agencies for recycled water systems.

AB 243 (**Kamlager-Dove** D) **Implicit bias training: peace officers.**
Introduced: 1/18/2019
Last Amend: 4/22/2019
Status: 8/30/2019-Failed Deadline pursuant to Rule 61(a)(12). (Last location was APPR. SUSPENSE FILE on 8/12/2019)(May be acted upon Jan 2020)

Location: 8/30/2019-S. 2 YEAR
Summary: Current law requires every peace officer to participate in expanded training prescribed by the Commission on Peace Officer Standards and Training that includes and examines evidence-based patterns, practices, and protocols that make up racial and identity profiling, including implicit bias. Once basic training is completed, current law requires specified peace officers to complete a refresher course on racial and identity profiling at least every 5 years. This bill would require those peace officers currently required to take the refresher course every 5 years, and additional peace officers, as specified, to instead take refresher training on racial and identity profiling, including the understanding of implicit bias and the promotion of bias-reducing strategies, at least every 2 years.

AB 255 **(Limón D) Coastal resources: oil spills: grants.**
Introduced: 1/23/2019
Status: 7/12/2019-Approved by the Governor. Chaptered by Secretary of State - Chapter 84, Statutes of 2019.
Location: 7/12/2019-A. CHAPTERED
Summary: The Lempert-Keene-Seastrand Oil Spill Prevention and Response Act authorizes the administrator for oil spill response to offer grants to a local government with jurisdiction over or directly adjacent to waters of the state to provide oil spill response equipment to be deployed by a certified local spill response manager, as provided.This bill would provide that Native American tribes and other public entities are also eligible to receive those grants.

AB 256 **(Aguiar-Curry D) Wildlife: California Winter Rice Habitat Incentive Program.**
Introduced: 1/23/2019
Last Amend: 9/3/2019
Status: 9/24/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/24/2019-A. ENROLLED
Summary: Current law requires the lessees of the rice lands to have the owners of record execute the contracts and defines "productive agricultural rice lands that are winter-flooded" for these purposes. Current law requires each contract to include, among other things, an agreement by the owner and any lessee to restore, enhance, and protect the waterfowl habitat character of the described land. This bill would no longer require the lessees of the rice lands to have the owners of record execute the contracts and would revise the definition of "productive agricultural rice lands that are winter-flooded." The bill would revise that agreement to instead require an agreement by the owner or the lessee to restore, enhance, and protect the waterfowl habitat character of an established number of acres of described land that may be annually rotated provided that the minimum contracted acreage amount is achieved for each of the contracted winter flooding seasons.

AB 273 **(Gonzalez D) Fur-bearing and nongame mammals: recreational and commercial fur trapping: prohibition.**
Introduced: 1/24/2019
Last Amend: 3/5/2019
Status: 9/4/2019-Approved by the Governor. Chaptered by Secretary of State - Chapter 216, Statutes of 2019.
Location: 9/4/2019-A. CHAPTERED
Summary: Would prohibit the trapping of any fur-bearing mammal or nongame mammal for purposes of recreation or commerce in fur and would prohibit the sale of the raw fur of any fur-bearing mammal or nongame mammal otherwise lawfully taken pursuant to the Fish and Game Code or regulations adopted pursuant to that code. Because a violation of these provisions would be a crime, this bill would impose a state-mandated local program. The bill would also make other conforming changes.

AB 284 **(Frazier D) Junior hunting licenses: eligibility: age requirement.**
Introduced: 1/28/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 4/3/2019)(May be acted upon Jan 2020)

Location: 5/17/2019-A. 2 YEAR
Summary: Current law requires the Department of Fish and Wildlife to issue various types of hunting licenses, including a discounted hunting license known as a junior hunting license, upon payment of a certain fee from an eligible applicant. Current law, until July 1, 2020, expands the eligibility for a junior hunting license from persons who are under 16 years of age on July 1 of the licensing year to persons who are under 18 years of age on July 1 of the licensing year, as specified, and makes conforming changes related to that expanded eligibility. This bill would extend, this expanded eligibility, for a junior hunting license indefinitely.

AB 286 **(Bonta D) Taxation: cannabis.**
Introduced: 1/28/2019
Last Amend: 4/3/2019
Status: 5/16/2019-In committee: Held under submission.
Location: 5/1/2019-A. APPR. SUSPENSE FILE
Summary: The Control, Regulate and Tax Adult Use of Marijuana Act imposes duties on the Bureau of Cannabis Control in the Department of Consumer Affairs, the Department of Food and Agriculture, and the State Department of Public Health with respect to the creation, issuance, denial, suspension and revocation of commercial cannabis licenses, and imposes an excise tax commencing January 1, 2018, on the purchase of cannabis and cannabis products at the rate of 15% of the average market price of any retail sale by a cannabis retailer. Commencing January 1, 2018, AUMA also imposes a cultivation tax upon all cultivators on all harvested cannabis that enters the commercial market, at specified rates per dry-weight ounce of cannabis flowers and leaves. This bill would reduce that excise tax rate to 11% on and after the operative date of this bill until July 1, 2022, at which time the excise tax rate would revert back to 15%.

AB 298 **(Mathis R) Housing: home purchase assistance program: first responders: Legislative Analyst: study and report.**
Introduced: 1/28/2019
Status: 5/3/2019-Failed Deadline pursuant to Rule 61(a)(3). (Last location was H. & C.D. on 2/15/2019)(May be acted upon Jan 2020)
Location: 5/3/2019-A. 2 YEAR
Summary: Would require the Legislative Analyst to conduct a study, and present the findings thereof to the Legislature, to inform the creation of a low-interest loan program for first responders. The bill would require the report to be submitted on or before January 1, 2024. The bill would require the report to include a recommendation as to which state department is best suited to administer the program, an estimation of the amount of funding that would be necessary to conduct the program, and recommendations for qualifications for participation in the program.

AB 312 **(Cooley D) State government: administrative regulations: review.**
Introduced: 1/29/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 4/3/2019)(May be acted upon Jan 2020)
Location: 5/17/2019-A. 2 YEAR
Summary: Would require each state agency to, on or before January 1, 2022, review its regulations, identify any regulations that are duplicative, overlapping, inconsistent, or out of date, revise those identified regulations, as provided, and report its findings and actions taken to the Legislature and Governor, as specified. The bill would repeal these provisions on January 1, 2023.

AB 352 **(Garcia, Eduardo D) Wildfire Prevention, Safe Drinking Water, Drought Preparation, and Flood Protection Bond Act of 2020.**
Introduced: 2/4/2019
Last Amend: 8/14/2019
Status: 8/14/2019-From committee chair, with author's amendments: Amend, and re-refer to committee. Read second time, amended, and re-referred to Com. on EQ.

Location: 8/14/2019-S. E.Q.
Summary: Would enact the Wildfire Prevention, Safe Drinking Water, Drought Preparation, and Flood Protection Bond Act of 2020, which, if approved by the voters, would authorize the issuance of bonds in the amount of $3,920,000,000 pursuant to the State General Obligation Bond Law to finance a wildlife prevention, safe drinking water, drought preparation, and flood protection program.The bill would provide for the submission of these provisions to the voters at the November 3, 2020, statewide general election.The bill would provide that its provisions are severable.

AB 392 (Weber D) **Peace officers: deadly force.**
Introduced: 2/6/2019
Last Amend: 5/23/2019
Status: 8/19/2019-Approved by the Governor. Chaptered by Secretary of State - Chapter 170, Statutes of 2019.
Location: 8/19/2019-A. CHAPTERED
Summary: Would redefine the circumstances under which a homicide by a peace officer is deemed justifiable to include when the officer reasonably believes, based on the totality of the circumstances, that deadly force is necessary to defend against an imminent threat of death or serious bodily injury to the officer or to another person, or to apprehend a fleeing person for a felony that threatened or resulted in death or serious bodily injury, if the officer reasonably believes that the person will cause death or serious bodily injury to another unless the person is immediately apprehended.

AB 394 (Obernolte R) **California Environmental Quality Act: exemption: egress route projects: fire safety.**
Introduced: 2/6/2019
Last Amend: 9/6/2019
Status: 9/23/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/23/2019-A. ENROLLED
Summary: Would, until January 1, 2025, exempt from CEQA egress route projects undertaken by a public agency that are specifically recommended by the State Board of Forestry and Fire Protection that improve the fire safety of an existing subdivision if certain conditions are met. The bill would require the lead agency to hold a noticed public meeting to hear and respond to public comments before determining that a project is exempt. The bill would require the lead agency, if it determines that a project is not subject to CEQA and approves or carries out that project, to file a notice of exemption with the Office of Planning and Research and with the clerk of the county in which the project will be located.

AB 430 (Gallagher R) **Housing development: Camp Fire Housing Assistance Act of 2019.**
Introduced: 2/7/2019
Last Amend: 8/27/2019
Status: 9/11/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/11/2019-A. ENROLLED
Summary: Current law authorizes a development proponent to submit an application for a development permit that is subject to a streamlined, ministerial approval process and not subject to a conditional use permit if the development satisfies specified objective planning standards, including that the development is a multifamily housing development that contains 2 or more residential units. This bill would authorize a development proponent to submit an application for a residential development, or mixed-use development that includes residential units with a specified percentage of space designated for residential use, within the territorial boundaries or a specialized residential planning area identified in the general plan of, and adjacent to existing urban development within, specified cities that is subject to a similar streamlined, ministerial approval process and not subject to a conditional use permit if the development satisfies specified objective planning standards.

AB 431 **(Gallagher R) California Environmental Quality Act: exemptions: projects in Town of Paradise and Butte County.**
Introduced: 2/7/2019
Last Amend: 3/19/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was NAT. RES. on 2/15/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: Would exempt from CEQA projects or activities related to the provision of sewer treatment or water service to the Town of Paradise or related to the improvement of evacuation routes in the Town of Paradise. The bill would also exempt from CEQA projects or activities undertaken by the Paradise Irrigation District related to the provision of water service.

AB 441 **(Eggman D) Water: underground storage.**
Introduced: 2/11/2019
Last Amend: 3/27/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 4/24/2019)(May be acted upon Jan 2020)
Location: 5/17/2019-A. 2 YEAR
Summary: Under current law, the right to water or to the use of water is limited to that amount of water that may be reasonably required for the beneficial use to be served. Current law provides for the reversion of water rights to which a person is entitled when the person fails to beneficially use the water for a period of 5 years. Current law declares that the storing of water underground, and related diversions for that purpose, constitute a beneficial use of water if the stored water is thereafter applied to the beneficial purposes for which the appropriation for storage was made. This bill would instead provide that any diversion of water to underground storage constitutes a diversion of water for beneficial use for which an appropriation may be made if the diverted water is put to beneficial use, as specified.

AB 448 **(Garcia, Eduardo D) Water rights: stockponds.**
Introduced: 2/11/2019
Last Amend: 4/3/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 4/24/2019)(May be acted upon Jan 2020)
Location: 5/17/2019-A. 2 YEAR
Summary: Would provide that the owner of a stockpond built prior to January 1, 2019, that does not have a capacity greater than 10 acre-feet may obtain a right to appropriate water for the principal purpose of watering livestock if that person files a claim for a water right with the State Water Resources Control Board accompanied by a fee not later than December 31, 2021, with certain exceptions. Upon the issuance of a certificate by the board for an appropriation of water obtained under the bill's provisions, the bill would require the board to provide in writing conditions to which the appropriation is subject.

AB 454 **(Kalra D) Migratory birds: California Migratory Bird Protection Act.**
Introduced: 2/11/2019
Last Amend: 5/16/2019
Status: 9/27/2019-Signed by the Governor
Location: 9/27/2019-A. CHAPTERED
Summary: The California Migratory Bird Protection Act, would instead, until January 20, 2025, make unlawful the taking or possession of any migratory nongame bird designated in the federal act before January 1, 2017, any additional migratory nongame bird that may be designated in the federal act after that date, or any part of those migratory nongame birds, except as provided by rules and regulations adopted by the United States Secretary of the Interior under the federal act before January 1, 2017, or subsequent rules or regulations adopted pursuant to the federal act, unless those rules or regulations are

inconsistent with the Fish and Game Code. This bill contains other related provisions and other existing laws.

AB 467 (**Boerner Horvath** D) **Competitions on state property: prize compensation: gender equity.**
Introduced: 2/11/2019
Last Amend: 6/14/2019
Status: 9/9/2019-Approved by the Governor. Chaptered by Secretary of State - Chapter 276, Statutes of 2019.
Location: 9/9/2019-A. CHAPTERED
Summary: Would require the Department of Parks and Recreation, the State Lands Commission and the California Coastal Commission to include in permit or lease conditions, for a competition event to be held on land under the jurisdiction of the entity, as described, and that awards prize compensation, as defined, to competitors in gendered categories, a requirement that the prize compensation be identical between the gendered categories at each participant level.

AB 527 (**Voepel** R) **Importation, possession, or sale of endangered wildlife.**
Introduced: 2/13/2019
Last Amend: 4/22/2019
Status: 6/4/2019-Failed Deadline pursuant to Rule 61(a)(8). (Last location was APPR. on 4/23/2019)
Location: 6/4/2019-A. 2 YEAR
Summary: Would delay the commencement of the prohibition on importing into the state for commercial purposes, possessing with intent to sell, or selling within the state, the dead body, or a part or product thereof, of a crocodile or alligator until January 1, 2030. The bill would also require a specified disclosure on all products sold in the state prior to January 1, 2030, failure to do so being punishable as a misdemeanor. By creating a new crime, this bill would impose a state-mandated local program.

AB 559 (**Arambula** D) **Millerton Lake State Recreation Area: acquisition of land.**
Introduced: 2/13/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was W.,P. & W. on 2/25/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: Would require the Department of Parks and Recreation to effectively manage lands currently within its jurisdiction in the Millerton Lake State Recreation Area adjacent to the San Joaquin River, and would authorize the department to enter into an agreement with the conservancy to manage lands acquired by the conservancy adjacent to the state recreation area, as specified.

AB 584 (**Gallagher** R) **Sport fishing licenses.**
Introduced: 2/14/2019
Status: 5/3/2019-Failed Deadline pursuant to Rule 61(a)(3). (Last location was PRINT on 2/14/2019)(May be acted upon Jan 2020)
Location: 5/3/2019-A. 2 YEAR
Summary: Current law requires every person 16 years of age or older who takes any fish, reptile, or amphibian for any purpose other than profit to first obtain a sport fishing license for that purpose, with specified exceptions, and to have that license on their person or in their immediate possession when engaged in carrying out any activity authorized by the license. This bill would make nonsubstantive changes to this provision.

AB 658 (**Arambula** D) **Water rights: water management.**
Introduced: 2/15/2019
Last Amend: 7/11/2019
Status: 9/24/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/24/2019-A. ENROLLED

Summary: Would authorize a groundwater sustainability agency or local agency to apply for, and the State Water Resources Control Board to issue, a conditional temporary permit for diversion of surface water to underground storage for beneficial use that advances the sustainability goal of a groundwater basin, as specified. This bill contains other related provisions and other existing laws.

AB 719 **(Rubio, Blanca D) Endangered wildlife: crocodiles and alligators.**
Introduced: 2/19/2019
Last Amend: 8/13/2019
Status: 8/30/2019-Failed Deadline pursuant to Rule 61(a)(12). (Last location was APPR. SUSPENSE FILE on 8/19/2019)(May be acted upon Jan 2020)
Location: 8/30/2019-S. 2 YEAR
Summary: Current law makes it a misdemeanor to import into the state for commercial purposes, to possess with intent to sell, or to sell within the state, the dead body, or a part or product thereof, of a polar bear, leopard, ocelot, tiger, cheetah, jaguar, sable antelope, wolf, zebra, whale, cobra, python, sea turtle, colobus monkey, kangaroo, vicuna, sea otter, free-roaming feral horse, dolphin, porpoise, Spanish lynx, or elephant. This bill would require manufacturers of products that use the hides of crocodiles or alligators, after consultation with the Department of Fish and Wildlife, to submit to the Director of Fish and Wildlife proposals for technologies or processes that allow for the tracking or tracing of the source of origin of crocodile or alligator hides used to manufacture products sold in this state and require humane treatment of farmed crocodiles and alligators, as well as humane slaughtering techniques. The bill would require the director, on or before March 30, 2021, to approve technologies or processes that meet those requirements.

AB 782 **(Berman D) California Environmental Quality Act: exemption: public agencies: land transfers.**
Introduced: 2/19/2019
Last Amend: 5/28/2019
Status: 8/30/2019-Approved by the Governor. Chaptered by Secretary of State - Chapter 181, Statutes of 2019.
Location: 8/30/2019-A. CHAPTERED
Summary: CEQA requires a lead agency to prepare a mitigated negative declaration for a project that may have a significant effect on the environment if revisions in the project would avoid or mitigate that effect and there is no substantial evidence that the project, as revised, would have a significant effect on the environment. This bill ould exempt from CEQA the acquisition, sale, or other transfer of interest in land by a public agency for certain purposes, or the granting or acceptance of funding by a public agency for those purposes.

AB 834 **(Quirk D) Freshwater and Estuarine Harmful Algal Bloom Program.**
Introduced: 2/20/2019
Last Amend: 8/30/2019
Status: 9/27/2019-Signed by the Governor
Location: 9/27/2019-A. CHAPTERED
Summary: Would require the State Water Resources Control Board to establish a Freshwater and Estuarine Harmful Algal Bloom Program to protect water quality and public health from harmful algal blooms. The bill would require the state board, in consultation with specified entities, among other things, to coordinate immediate and long-term algal bloom event incident response, as provided, and conduct and support algal bloom field assessment and ambient monitoring at the state, regional, watershed, and site-specific waterbody scales.

AB 855 **(McCarty D) Department of Justice: law enforcement policies on the use of deadly force.**
Introduced: 2/20/2019
Last Amend: 3/19/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was PUB. S. on 3/18/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR

Summary: Would require the Attorney General to convene a task force, as specified, to study the use of deadly force by law enforcement officers and to develop recommendations, including a model written policy, for law enforcement agencies.

AB 883 **(Dahle R) Fish and wildlife: catastrophic wildfires: report.**
Introduced: 2/20/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 4/24/2019)(May be acted upon Jan 2020)
Location: 5/17/2019-A. 2 YEAR
Summary: Would require the Department of Fish and Wildlife, in consultation with the Department of Forestry and Fire Protection, on or before December 31, 2020, and by December 31 each year thereafter, to study, investigate, and report to the Legislature on the impacts on wildlife and wildlife habitat resulting from any catastrophic wildfire, as defined, that occurred during that calendar year, including specified information on a catastrophic wildfire's impact on ecosystems, biodiversity, and protected species in the state.

AB 889 **(Maienschein D) Animal research.**
Introduced: 2/20/2019
Last Amend: 4/1/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was HEALTH on 3/4/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: Current law prohibits the keeping or use of animals for diagnostic purposes, education, or research without approval by the State Department of Public Health. Current law authorizes the department to prescribe rules under which persons who wish to keep or use animals for those purposes may obtain approval from the department, and to promulgate regulations governing the use of animals for those purposes. Current law exempts certain persons from those requirements, including persons who use or keep animals for animal training and animal cosmetics, among other things. This bill would define "animal" for purposes of these provisions as any live vertebrate nonhuman animal used for diagnostic purposes, education, or research, as specified.

AB 935 **(Rivas, Robert D) Oil and gas: facilities and operations: monitoring and reporting.**
Introduced: 2/20/2019
Last Amend: 3/21/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was NAT. RES. on 3/21/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: Under current law, the Division of Oil, Gas, and Geothermal Resources in the Department of Conservation regulates the drilling, operation, maintenance, and abandonment of oil and gas wells in the state. Current law defines various terms for those purposes, including "production facility. This bill "Would define the term "sensitive production facility" for those purposes to mean a production facility that is located within certain areas, including, among others, an area containing a building intended for human occupancy that is located within 2,500 feet of the production facility.

AB 936 **(Rivas, Robert D) Oil spills: response and contingency planning.**
Introduced: 2/20/2019
Last Amend: 9/6/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/19/2019-A. ENROLLED
Summary: Would define "nonfloating oil" for purposes of the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act. The bill would require the administrator to hold, on or before January 1, 2022, a technology workshop that shall include the topic of technology for addressing nonfloating oil spills, and, in fulfilling specified duties, to consider information gained from technology workshops, as well as available scientific and technical literature concerning nonfloating oil spill response technology.

The bill would require the administrator to include in the revision to the California oil spill contingency plan due on or before January 1, 2023, provisions addressing nonfloating oil.

AB 948 **(Kalra D) Coyote Valley Conservation Program.**
Introduced: 2/20/2019
Last Amend: 8/12/2019
Status: 9/27/2019-Signed by the Governor
Location: 9/27/2019-A. CHAPTERED
Summary: Would authorize the authority to establish and administer the Coyote Valley Conservation Program to address resource and recreational goals of the Coyote Valley, as defined. The bill would authorize the authority to collaborate with state, regional, and local partners to help achieve specified goals of the program. The bill would authorize the authority to, among other things, acquire and dispose of interests and options in real property. The bill would require a proponent or party to a certain proposed development project within Coyote Valley to provide notice to the authority of the proposed project, and would authorize the authority to provide analysis of the environmental values and potential impacts of the proposed project. The bill would require Coyote Valley to be acknowledged as an area of statewide significance in local planning documents developed or updated on or after January 1, 2020, affecting land use within Coyote Valley. To the extent that this bill would impose new duties on local entities, it would impose a state-mandated local program. This bill contains other related provisions and other existing laws.

AB 1013 **(Obernolte R) State agencies: grant applications.**
Introduced: 2/21/2019
Last Amend: 8/20/2019
Status: 9/11/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/11/2019-A. ENROLLED
Summary: Current law authorizes various state agencies to award grant money for various purposes.This bill would prohibit a state agency from permitting an evaluator to review a discretionary grant application submitted by an organization or a person for which the evaluator was a representative, voting member, or staff member within the 2-year period preceding receipt of that application.

AB 1040 **(Muratsuchi D) Protection of cetaceans: unlawful activities.**
Introduced: 2/21/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was W.,P. & W. on 3/7/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: Current law makes it unlawful to hold in captivity an orca, whether wild caught or captive bred, for any purpose, including for display, performance, or entertainment purposes; to breed or impregnate an orca held in captivity; to export, collect, or import the semen, other gametes, or embryos of an orca held in captivity for the purpose of artificial insemination; or to export, transport, move, or sell an orca located in the state to another state or country. Current law creates certain exceptions to these provisions, including an exception that authorizes an orca located in the state on January 1, 2017, to continue to be held in captivity for its current purpose and, after June 1, 2017, to continue to be used for educational presentations. This bill would expand these provisions to include cetaceans, which the bill would define to mean a whale, dolphin, and porpoise in the order Cetacea.

AB 1117 **(Grayson D) Peace officers: peer support.**
Introduced: 2/21/2019
Last Amend: 9/6/2019
Status: 9/23/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/23/2019-A. ENROLLED
Summary: The California Emergency Services Act also authorizes the governing body of a city, county, city and county, or an official designated by ordinance adopted by that governing body, to proclaim a local emergency, as defined. This bill would enact the Law Enforcement Peer Support and

Crisis Referral Services Program. The bill would authorize a local or regional law enforcement agency to establish a peer support and crisis referral program to provide an agencywide network of peer representatives available to aid fellow employees on emotional or professional issues. The bill would, for purposes of the act, define a "peer support team" as a team composed of law enforcement personnel, as defined, who have completed a peer support training course, as specified.

AB 1149 **(Fong R) California Environmental Quality Act: record of proceedings.**
Introduced: 2/21/2019
Last Amend: 4/23/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was NAT. RES. on 3/25/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: CEQA requires a lead agency to prepare a mitigated negative declaration for a project that may have a significant effect on the environment if revisions in the project would avoid or mitigate that effect and there is no substantial evidence that the project, as revised, would have a significant effect on the environment. In an action or proceeding alleging the lead agency violated the act, the act requires the lead agency to prepare and certify the record of proceedings and requires the parties to pay any reasonable costs or fees imposed for the preparation of the record of proceedings, as specified.

AB 1160 **(Dahle R) Forestry: timber operations: sustained yield plans.**
Introduced: 2/21/2019
Last Amend: 4/11/2019
Status: 7/12/2019-Approved by the Governor. Chaptered by Secretary of State - Chapter 108, Statutes of 2019.
Location: 7/12/2019-A. CHAPTERED
Summary: The Z'berg-Nejedly Forest Practice Act of 1973 prohibits a person from conducting timber operations, as defined, unless a timber harvesting plan prepared by a registered professional forester has been submitted to, and approved by, the Department of Forestry and Fire Protection. The act requires the State Board of Forestry and Fire Protection to adopt district forest practice rules and regulations, as provided, and requires a sustained yield plan that is prepared and approved in accordance with these rules and regulations to be effective for a period of no more than 10 years.This bill would instead require the sustained yield plan to be effective for a period of no more than 20 years.

AB 1184 **(Gloria D) Public records: writing transmitted by electronic mail: retention.**
Introduced: 2/21/2019
Last Amend: 8/30/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/19/2019-A. ENROLLED
Summary: Would, unless a longer retention period is required by statute or regulation, or established by the Secretary of State pursuant to the State Records Management Act, require a public agency, for purposes of the California Public Records Act, to retain and preserve for at least 2 years every public record, as defined, that is transmitted by electronic mail.

AB 1190 **(Irwin D) Unmanned aircraft: state and local regulation: limitations.**
Introduced: 2/21/2019
Last Amend: 5/1/2019
Status: 6/19/2019-Referred to Com. on RLS.
Location: 5/24/2019-S. RLS.
Summary: Would, among other things, prohibit a state or local agency from adopting any law or regulation that bans the operation of an unmanned aircraft system. The bill would also authorize a local agency to adopt regulations to enforce FAA regulations regarding the operation of unmanned aircraft systems and would authorize local agencies to regulate the operation of unmanned aircraft and unmanned aircraft systems within their jurisdictions, as specified. The bill would also authorize a local

agency to require an unmanned aircraft operator to provide proof of federal, state, or local registration to licensing or enforcement officials.

AB 1197 **(Santiago D) California Environmental Quality Act: exemption: City of Los Angeles: supportive housing and emergency shelters.**
Introduced: 2/21/2019
Last Amend: 9/6/2019
Status: 9/26/2019-Chaptered by Secretary of State- Chapter 340, Statutes of 2019
Location: 9/26/2019-A. CHAPTERED
Summary: The California Environmental Quality Act (CEQA) requires a lead agency, as defined, to prepare, or cause to be prepared, and certify the completion of an environmental impact report on a project that it proposes to carry out or approve that may have a significant effect on the environment or to adopt a negative declaration if it finds that the project will not have that effect. CEQA also requires a lead agency to prepare a mitigated negative declaration for a project that may have a significant effect on the environment if revisions in the project would avoid or mitigate that effect and there is no substantial evidence that the project, as revised, would have a significant effect on the environment. This bill would, until January 1, 2025, exempt from the requirements of CEQA certain activities approved or carried out by the City of Los Angeles and other eligible public agencies, as defined, related to supportive housing and emergency shelters, as defined.

AB 1237 **(Aguiar-Curry D) Greenhouse Gas Reduction Fund: guidelines.**
Introduced: 2/21/2019
Last Amend: 8/13/2019
Status: 9/27/2019-Signed by the Governor
Location: 9/27/2019-A. CHAPTERED
Summary: Current law requires the Department of Finance to annually submit a report to the appropriate committees of the Legislature on the status of the projects funded with moneys from the Greenhouse Gas Reduction Fund. This bill, no later than January 1, 2021, would require an agency that receives an appropriation from the Greenhouse Gas Reduction Fund to post on the internet website of the agency's program from which moneys from the fund are being allocated the guidelines, as specified, for how moneys from the fund are allocated for competitive financing programs, as specified.

AB 1244 **(Fong R) Environmental quality: judicial review: housing projects.**
Introduced: 2/21/2019
Status: 5/3/2019-Failed Deadline pursuant to Rule 61(a)(3). (Last location was NAT. RES. on 3/11/2019)(May be acted upon Jan 2020)
Location: 5/3/2019-A. 2 YEAR
Summary: Would, in an action or proceeding seeking judicial review under the California Environmental Quality Act, prohibit a court from staying or enjoining a housing project for which an environmental impact report has been certified, unless the court makes specified findings.

AB 1254 **(Kamlager-Dove D) Bobcats: take prohibition: hunting season: management plan.**
Introduced: 2/21/2019
Last Amend: 9/5/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/19/2019-A. ENROLLED
Summary: Current law authorizes nongame mammals, among other specified species, that are found to be injuring growing crops or other property to be taken at any time or in any manner by specified persons in accordance with the Fish and Game Code and regulations adopted pursuant to that code. Current law authorizes the department to enter into cooperative agreements with any state or federal agency for the purpose of controlling harmful nongame mammals. Current law also authorizes the department to enter into cooperative contracts with the United States Fish and Wildlife Service for the control of nongame mammals. This bill would make it unlawful to hunt, trap, or otherwise take a

bobcat, except under specified circumstances, including under a depredation permit. The bill, upon appropriation of funds by the Legislature for this purpose, commencing January 1, 2025, would authorize the commission to open a bobcat hunting season in any area determined by the commission to require a hunt, as specified.

AB 1260 **(Maienschein D) Endangered wildlife.**
Introduced: 2/21/2019
Last Amend: 4/11/2019
Status: 9/11/2019-Enrolled and presented to the Governor at 3:30 p.m.
Location: 9/11/2019-A. ENROLLED
Summary: Would, commencing January 1, 2022, make it a misdemeanor to import into the state for commercial purposes, to possess with intent to sell, or to sell within the state, the dead body or other part or product of an iguana, skink, caiman, hippopotamus, or a Teju, Ring, or Nile lizard. By creating a new crime, the bill would impose a state-mandated local program.

AB 1305 **(Obernolte R) Junior hunting licenses: eligibility: age requirement.**
Introduced: 2/22/2019
Last Amend: 6/18/2019
Status: 6/19/2019-Withdrawn from committee. Re-referred to Com. on RLS.
Location: 6/19/2019-S. RLS.
Summary: Current law requires the Department of Fish and Wildlife to issue various types of hunting licenses, including a discounted hunting license known as a junior hunting license, upon payment of a certain fee from an eligible applicant. Current law provides that, until July 1, 2020, a person is eligible for a junior hunting license if the person is under 18 years of age on July 1 of the licensing year. Existing law provides that, on and after July 1, 2020, a person is eligible for a junior hunting license if the person is under 16 years of age on July 1 of the licensing year. Current law makes conforming changes to certain other types of hunting licenses as a result of the age change for a junior hunting license. This bill would extend the eligibility for a junior hunting license to a person who is under 18 years of age on July 1 of the licensing year until July 1, 2021.

AB 1387 **(Wood D) Sport fishing licenses: 12-consecutive-month licenses.**
Introduced: 2/22/2019
Last Amend: 5/20/2019
Status: 7/10/2019-Failed Deadline pursuant to Rule 61(a)(10). (Last location was N.R. & W. on 6/12/2019)(May be acted upon Jan 2020)
Location: 7/10/2019-S. 2 YEAR
Summary: Current law requires a resident or a nonresident, 16 years of age or older, upon payment of a specified fee, to be issued a sport fishing license for the period of a calendar year, or, if issued after the beginning of the year, for the remainder thereof. Existing law also requires the issuance of shorter term licenses upon payment of a specified lesser fee. This bill, in addition to sport fishing licenses for the periods specified above, would require a sport fishing license to be issued to a resident or nonresident for the period of 12 consecutive months, upon payment of a fee that is equal to 130% of the fees for issuance of resident or nonresident calendar-year sport fishing licenses, as applicable.

AB 1472 **(Stone, Mark D) California Dungeness Crab Commission.**
Introduced: 2/22/2019
Last Amend: 6/19/2019
Status: 9/15/2019-Failed Deadline pursuant to Rule 61(a)(15). (Last location was INACTIVE FILE on 9/12/2019)(May be acted upon Jan 2020)
Location: 9/15/2019-A. 2 YEAR
Summary: Would create the California Dungeness Crab Commission. The bill would specify the membership, powers, duties, and responsibilities of the commission. The commission would be authorized to approve the payment of a stipend to commission members, as specified. The commission also would be authorized to carry out programs of education, public information, promotion,

marketing, and research relating to Dungeness crab. The bill would authorize the commission to levy an assessment, as specified, on Dungeness crab fishers, as defined, and would authorize the expenditure of those moneys for the purposes of carrying out the commission's powers, duties, and responsibilities, thereby making an appropriation.

AB 1549 (**O'Donnell** D) **Wildlife: deer: Santa Catalina Island: report.**
Introduced: 2/22/2019
Last Amend: 3/21/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 4/24/2019)(May be acted upon Jan 2020)
Location: 5/17/2019-A. 2 YEAR
Summary: Would require the Department of Fish and Wildlife to develop, by January 1, 2022, a report, in consultation with other relevant state agencies, local governments, federal agencies, nongovernmental organizations, landowners, and scientific entities, to inform and coordinate management decisions regarding deer on Santa Catalina Island that includes, among other things, estimates of the historic, current, and future deer population on the island and an assessment of the overall health of the deer population on the island.

AB 1561 (**Rubio, Blanca** D) **Endangered wildlife: crocodiles and alligators.**
Introduced: 2/22/2019
Last Amend: 9/6/2019
Status: 9/9/2019-Read second time. Ordered to third reading. Re-referred to Com. on RLS. pursuant to Senate Rule 29.10(c).
Location: 9/9/2019-S. RLS.
Summary: Would delay the commencement of the prohibition on importing into the state for commercial purposes, possessing with intent to sell, or selling within the state, the dead body, or a part or product thereof, of a crocodile or alligator until January 1, 2021.This bill contains other related provisions.

AB 1612 (**Quirk** D) **Department of Fish and Wildlife: Invasive Species Response Fund.**
Introduced: 2/22/2019
Last Amend: 3/28/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was W.,P. & W. on 3/28/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-A. 2 YEAR
Summary: Would establish the Invasive Species Response Fund in the State Treasury and would continuously appropriate money deposited in the fund to the Department of Fish and Wildlife to respond to nonnative vertebrate species invasions in coordination with other relevant government agencies. The bill would require any money received by the department from the federal government for the purpose of controlling and eradicating nonnative vertebrate species to be deposited in the fund.

AB 1657 (**Garcia, Eduardo** D) **Salton Sea: Office of the Salton Sea: Salton Sea Oversight Committee.**
Introduced: 2/22/2019
Status: 7/10/2019-Failed Deadline pursuant to Rule 61(a)(10). (Last location was N.R. & W. on 6/12/2019)(May be acted upon Jan 2020)
Location: 7/10/2019-S. 2 YEAR
Summary: The Salton Sea Restoration Act requires the Secretary of the Natural Resources Agency, in consultation and coordination with the Salton Sea Authority, to lead Salton Sea restoration efforts.This bill would establish an Office of the Salton Sea within the Natural Resources Agency. The bill would require the secretary to establish a Salton Sea Oversight Committee.

AB 1788 (**Bloom** D) **Pesticides: use of anticoagulants.**
Introduced: 2/22/2019
Last Amend: 6/24/2019

Status: 8/30/2019-Failed Deadline pursuant to Rule 61(a)(12). (Last location was APPR. on 7/9/2019)(May be acted upon Jan 2020)
Location: 8/30/2019-S. 2 YEAR
Summary: Current law prohibits the use of any pesticide that contains one or more of specified anticoagulants in wildlife habitat areas, as defined. Current law exempts from this prohibition the use of these pesticides for agricultural activities, as defined. Existing law requires the director, and each county agricultural commissioner under the direction and supervision of the director, to enforce the provisions regulating the use of pesticides. This bill would create the California Ecosystems Protection Act of 2019 and expand this prohibition against the use of a pesticide containing specified anticoagulants in wildlife habitat areas to the entire state.

AB 1798 **(Levine D) California Racial Justice Act: death penalty.**
Introduced: 2/22/2019
Last Amend: 3/21/2019
Status: 5/17/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 5/1/2019)(May be acted upon Jan 2020)
Location: 5/17/2019-A. 2 YEAR
Summary: Would prohibit a person from being executed pursuant to a judgment that was either sought or obtained on the basis of race if the court makes a finding that race was a significant factor in seeking or imposing the death penalty. The bill would provide that a finding that race was a significant factor would include statistical evidence or other evidence that death sentences were sought or imposed significantly more frequently upon persons of one race than upon persons of another race or that race was a significant factor in decisions to exercise preemptory challenges during jury selection.

SB 1 **(Atkins D) California Environmental, Public Health, and Workers Defense Act of 2019.**
Introduced: 12/3/2018
Last Amend: 9/10/2019
Status: 9/27/2019-Vetoed by the Governor. In Senate. Consideration of Governor's veto pending.
Location: 9/27/2019-S. VETOED
Summary: Current state law regulates the discharge of air pollutants into the atmosphere. The Porter-Cologne Water Quality Control Act regulates the discharge of pollutants into the waters of the state. The California Safe Drinking Water Act establishes standards for drinking water and regulates drinking water systems. The California Endangered Species Act requires the Fish and Game Commission to establish a list of endangered species and a list of threatened species, and generally prohibits the taking of those species. This bill would, until January 20, 2025, require specified agencies to take prescribed actions regarding certain federal requirements and standards pertaining to air, water, and protected species, as specified. By imposing new duties on local agencies, this bill would impose a state-mandated local program.

SB 4 **(McGuire D) Housing.**
Introduced: 12/3/2018
Last Amend: 4/10/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was GOV. & F. on 4/2/2019)(May be acted upon Jan 2020)
Location: 4/26/2019-S. 2 YEAR
Summary: Would authorize a development proponent of a neighborhood multifamily project or eligible transit-oriented development (TOD) project located on an eligible parcel to submit an application for a streamlined, ministerial approval process that is not subject to a conditional use permit. The bill would define a “neighborhood multifamily project” to mean a project to construct a multifamily unit of up to 2 residential dwelling units in a nonurban community, as defined, or up to 4 residential dwelling units in an urban community, as defined, that meets local height, setback, and lot coverage zoning requirements as they existed on July 1, 2019.

SB 19 **(Dodd D) Water resources: stream gages.**
Introduced: 12/3/2018
Last Amend: 6/11/2019
Status: 9/27/2019-Signed by the Governor
Location: 9/27/2019-S. CHAPTERED
Summary: Would require the Department of Water Resources and the State Water Resources Control Board, upon an appropriation of funds by the Legislature, to develop a plan to deploy a network of stream gages that includes a determination of funding needs and opportunities for modernizing and reactivating existing gages and deploying new gages, as specified. The bill would require the department and the board, in consultation with the Department of Fish and Wildlife, the Department of Conservation, the Central Valley Flood Protection Board, interested stakeholders, and, to the extent they wish to consult, local agencies, to develop the plan to address significant gaps in information necessary for water management and the conservation of freshwater species.

SB 34 **(Wiener D) Cannabis: donations.**
Introduced: 12/3/2018
Last Amend: 9/6/2019
Status: 9/18/2019-Enrolled and presented to the Governor at 4 p.m.
Location: 9/18/2019-S. ENROLLED
Summary: Current administrative law prohibits a cannibis retailer licensee from providing free cannabis goods to any person or allowing individuals who are not employed by the retailer to provide free cannabis goods to any person on the licensed premises. Current administrative law provides an exception to this prohibition for specified medicinal retailer and microbusiness licensees to provide access to medicinal cannabis patients who have difficulty accessing medicinal cannabis goods, as specified. This bill, the Dennis Peron and Brownie Mary Act, would similarly authorize, on and after a specified date, licensees that are authorized to make retail sales to provide free cannabis or cannabis products to a medicinal cannabis patient or the patient's primary caregiver if specified requirements are met, including that the cannabis or cannabis products otherwise meet specified requirements of MAUCRSA.

SB 45 **(Allen D) Wildfire Prevention, Safe Drinking Water, Drought Preparation, and Flood Protection Bond Act of 2020.**
Introduced: 12/3/2018
Last Amend: 9/10/2019
Status: 9/10/2019-Senate Rule 29.3(b) suspended. (Ayes 29. Noes 8.) From committee with author's amendments. Read second time and amended. Re-referred to Com. on APPR.
Location: 4/25/2019-S. APPR.
Summary: Would enact the Wildfire Prevention, Safe Drinking Water, Drought Preparation, and Flood Protection Bond Act of 2020, which, if approved by the voters, would authorize the issuance of bonds in the amount of $4,189,000,000 pursuant to the State General Obligation Bond Law to finance projects for a wildfire prevention, safe drinking water, drought preparation, and flood protection program.

SB 50 **(Wiener D) Planning and zoning: housing development: streamlined approval: incentives.**
Introduced: 12/3/2018
Last Amend: 6/4/2019
Status: 6/4/2019-Failed Deadline pursuant to Rule 61(a)(5). (Last location was APPR. SUSPENSE FILE on 5/13/2019)(May be acted upon Jan 2020)
Location: 6/4/2019-S. 2 YEAR
Summary: Would authorize a development proponent of a neighborhood multifamily project located on an eligible parcel to submit an application for a streamlined, ministerial approval process that is not subject to a conditional use permit. The bill would define a "neighborhood multifamily project" to mean a project to construct a multifamily structure on vacant land, or to convert an existing structure that does not require substantial exterior alteration into a multifamily structure, consisting of up to 4

residential dwelling units and that meets local height, setback, and lot coverage zoning requirements as they existed on July 1, 2019.

SB 62 **(Dodd D) Endangered species: accidental take associated with routine and ongoing agricultural activities: state safe harbor agreements.**
Introduced: 1/3/2019
Last Amend: 4/3/2019
Status: 7/30/2019-Approved by the Governor. Chaptered by Secretary of State. Chapter 137, Statutes of 2019.
Location: 7/30/2019-S. CHAPTERED
Summary: The California Endangered Species Act requires the Department of Fish and Wildlife to adopt regulations for the issuance of incidental take permits. The act also provides, until January 1, 2020, that the accidental take of candidate, threatened, or endangered species resulting from an act that occurs on a farm or a ranch in the course of otherwise lawful routine and ongoing agricultural activities is not prohibited by the act. This bill would extend this exception to January 1, 2024, and would limit this exception to an act by a person acting as a farmer or rancher, a bona fide employee of a farmer or rancher, or an individual otherwise contracted by a farmer or rancher.

SB 69 **(Wiener D) Ocean Resiliency Act of 2019.**
Introduced: 1/9/2019
Last Amend: 7/11/2019
Status: 8/30/2019-Failed Deadline pursuant to Rule 61(a)(12). (Last location was APPR. SUSPENSE FILE on 8/21/2019)(May be acted upon Jan 2020)
Location: 8/30/2019-A. 2 YEAR
Summary: Current law requires the Fish and Game Commission to establish fish hatcheries for the purposes of stocking the waters of California with fish, and requires the Department of Fish and Wildlife to maintain and operate those hatcheries. This bill would require the department to develop and implement a plan, in collaboration with specified scientists, experts, and representatives, as part of its fish hatchery operations for the improvement of the survival of hatchery-produced salmon, and the increased contribution of the hatchery program to commercial and recreational salmon fisheries.

SB 85 **(Committee on Budget and Fiscal Review) Public resources: omnibus trailer bill.**
Introduced: 1/10/2019
Last Amend: 6/11/2019
Status: 6/27/2019-Approved by the Governor. Chaptered by Secretary of State. Chapter 31, Statutes of 2019.
Location: 6/27/2019-S. CHAPTERED
Summary: Would require the Controller to continue to annually transfer $30,000,000 from the General Fund, less any amount transferred to the Habitat Conservation Fund from specified accounts and funds, to the Habitat Conservation Fund until June 30, 2030, and would continuously appropriate that amount on an annual basis in the same proportions to the specified entities until July 1, 2030. The bill would also make conforming and nonsubstantive changes.

SB 183 **(Borgeas R) Property: wild animals.**
Introduced: 1/29/2019
Status: 2/6/2019-Referred to Com. on RLS.
Location: 1/29/2019-S. RLS.
Summary: Current law provides that animals that are wild by nature may be the subject of ownership while those animals are living only in specified circumstances.This bill would make nonsubstantive changes to that provision of law.

SB 195 **(Nielsen R) Sierra Nevada Conservancy.**
Introduced: 1/31/2019
Status: 2/13/2019-Referred to Com. on RLS.

Location: 1/31/2019-S. RLS.
Summary: Current law establishes the Sierra Nevada Conservancy and prescribes the functions and duties of the conservancy with regard to the preservation of specified lands in the Sierra Nevada Region, as defined. Current law makes specified findings and declarations relating to the importance and significance of the Sierra Nevada Region and the need to protect, conserve, restore, and enhance lands within the region.This bill would make nonsubstantive changes in those findings and declarations.

SB 198 (**Bates** **R**) **California Environmental Quality Act: historical resources.**
Introduced: 1/31/2019
Status: 2/13/2019-Referred to Com. on RLS.
Location: 1/31/2019-S. RLS.
Summary: CEQA provides that a project may have a significant effect on the environment if the project may cause a substantial adverse change in the significance of a historical resource. This bill would make nonsubstantive changes in the provision relating to historical resources.

SB 226 (**Nielsen** **R**) **Watershed restoration: wildfires: grant program.**
Introduced: 2/7/2019
Last Amend: 7/3/2019
Status: 8/30/2019-Failed Deadline pursuant to Rule 61(a)(12). (Last location was APPR. SUSPENSE FILE on 8/14/2019)(May be acted upon Jan 2020)
Location: 8/30/2019-A. 2 YEAR
Summary: Would, upon appropriation by the Legislature, require the National Resources Agency to develop and implement a watershed restoration grant program, as provided, for purposes of awarding grants to eligible counties, as defined, to assist them with watershed restoration on watersheds that have been affected by wildfire, as specified. The bill would require the agency to develop guidelines for the grant program, as provided. The bill would require an eligible county receiving funds pursuant to the grant program to submit annually to the agency a report regarding projects funded by the grant program, as provided.

SB 230 (**Caballero** **D**) **Law enforcement: use of deadly force: training: policies.**
Introduced: 2/7/2019
Last Amend: 9/3/2019
Status: 9/13/2019-Chaptered by Secretary of State. Chapter 285, Statutes of 2019.
Location: 9/12/2019-S. CHAPTERED
Summary: Would, by no later than January 1, 2021, require each law enforcement agency to maintain a policy that provides guidelines on the use of force, utilizing deescalation techniques and other alternatives to force when feasible, specific guidelines for the application of deadly force, and factors for evaluating and reviewing all use of force incidents, among other things. The bill would require each agency to make their use of force policy accessible to the public. By imposing additional duties on local agencies, this bill would create a state-mandated local program.

SB 243 (**Borgeas** **R**) **San Joaquin River Conservancy.**
Introduced: 2/11/2019
Status: 2/21/2019-Referred to Com. on RLS.
Location: 2/11/2019-S. RLS.
Summary: Current law establishes the San Joaquin River Conservancy and prescribes the functions and responsibilities of the conservancy with regard to the protection and conservation of public lands in the San Joaquin River Parkway, as described. Current law requires the conservancy to administer any funds appropriated to it and any revenue generated by member agencies of the conservancy for the parkway and contributed to the conservancy, and authorizes the conservancy to expend those funds for capital improvements, land acquisitions, or support of the conservancy's operations. This bill would make a nonsubstantive change in that provision requiring the conservancy to administer those funds.

SB 247 **(Dodd D) Wildland fire prevention: vegetation management.**
Introduced: 2/11/2019
Last Amend: 9/3/2019
Status: 9/18/2019-Enrolled and presented to the Governor at 4 p.m.
Location: 9/18/2019-S. ENROLLED
Summary: Would require an electrical corporation, within one month of the completion of each substantial portion of the vegetation management requirements in its wildfire mitigation plan, to notify the Wildfire Safety Division of the completion. The bill would require the division to audit the completed work and would require the audit to specify any failure of the electrical corporation to fully comply with the vegetation management requirements. The bill would require the division to provide the audit to the electrical corporation and to provide the electrical corporation a reasonable time period to correct and eliminate deficiencies specified in the audit.

SB 262 **(McGuire D) Marine resources: commercial fishing and aquaculture: regulation of operations.**
Introduced: 2/12/2019
Last Amend: 9/3/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Current law regulating commercial fishing imposes, or authorizes the imposition of, various license, permit, and registration fees. Current law requires specified persons to pay landing fees relating to the sale of fish quarterly to the Department of Fish and Wildlife, based on a rate schedule applicable to listed aquatic species. Current law authorizes the department to assess a fee on persons growing aquaculture products on public lands and in public waters based on the price per pound of the products sold, not to exceed the rates provided in the rate schedule applicable to wild-caught aquatic species. This bill would make that landing fee rate schedule applicable to the 2020 calendar year, and require that the schedule be adjusted annually thereafter pursuant to that specified federal index.

SB 307 **(Roth D) Water conveyance: use of facility with unused capacity.**
Introduced: 2/15/2019
Last Amend: 4/30/2019
Status: 7/31/2019-Approved by the Governor. Chaptered by Secretary of State. Chapter 169, Statutes of 2019.
Location: 7/31/2019-S. CHAPTERED
Summary: Current law prohibits the state or a regional or local public agency from denying a bona fide transferor of water from using a water conveyance facility that has unused capacity for the period of time for which that capacity is available, if fair compensation is paid for that use and other requirements are met. This bill would, notwithstanding that provision, prohibit a transferor of water from using a water conveyance facility that has unused capacity to transfer water from a groundwater basin underlying desert lands, as defined, that is in the vicinity of specified federal lands or state lands to outside of the groundwater basin unless the State Lands Commission, in consultation with the Department of Fish and Wildlife and the Department of Water Resources, finds that the transfer of the water will not adversely affect the natural or cultural resources of those federal or state lands, as provided.

SB 313 **(Hueso D) Animals: prohibition on use in circuses.**
Introduced: 2/15/2019
Last Amend: 8/12/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Would prohibit a person from sponsoring, conducting, or operating a circus, as defined, in this state that uses any animal other than a domestic dog, domestic cat, or domesticated horse. The bill would prohibit a person from exhibiting or using any animal other than a domestic dog, domestic cat, or domesticated horse in a circus in this state. The bill would authorize a civil penalty against a person who violates these prohibitions pursuant to an action brought by the Attorney General, the Department

of Fish and Wildlife, the Department of Food and Agriculture, a district attorney, a city attorney, or a city prosecutor.

SB 376 **(Portantino D) Firearms: transfers.**
Introduced: 2/20/2019
Last Amend: 9/6/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Current law generally requires any person who sells, leases, or transfers firearms to be a licensed dealer, as specified. Current law exempts infrequent sales, leases, and transfers from this requirement. Current law generally prohibits the purchase or receipt of a firearm by, or sale, transfer, or loan of a firearm, to, a person who does not have a firearm safety certificate. Current law exempts from this requirement, the infrequent loan of a firearm. Current law defines “infrequent” for purposes of this exemption to mean less than 6 handgun transactions per calendar year, or, for firearms other than handguns, an indefinite number of transactions that are “occasional and without regularity.” This bill would redefine “infrequent” to mean less than 6 firearm transactions per calendar year, regardless of the type of firearm, and no more than 50 total firearms within those transactions

SB 395 **(Archuleta D) Wild game mammals: accidental taking and possession of wildlife: collision with a vehicle: wildlife salvage permits.**
Introduced: 2/20/2019
Last Amend: 9/6/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Would, upon appropriation by the Legislature, authorize the Fish and Game Commission to establish, in consultation with specified public agencies and stakeholders, a pilot program no later than January 1, 2022, for the issuance of wildlife salvage permits through a user-friendly and cell-phone-friendly web-based portal developed by the Department of Fish and Wildlife to persons desiring to recover, possess, use, or transport, for purposes of salvaging wild game meat for human consumption of, any deer, elk, pronghorn antelope, or wild pig that has been accidentally killed as a result of a vehicle collision on a roadway within California.

SB 402 **(Borgeas R) Vehicles: off-highway vehicle recreation: County of Inyo.**
Introduced: 2/20/2019
Last Amend: 5/13/2019
Status: 8/30/2019-Approved by the Governor. Chaptered by Secretary of State. Chapter 211, Statutes of 2019.
Location: 8/30/2019-S. CHAPTERED
Summary: Current law, until January 1, 2020, authorizes the County of Inyo to establish a pilot project that would exempt specified combined-use highways in the unincorporated area in the County of Inyo from this prohibition to link together existing roads in the unincorporated portion of the county to existing trails and trailheads on federal Bureau of Land Management or United States Forest Service lands in order to provide a unified linkage of trail systems for off-highway motor vehicles, as prescribed. Current law requires the County of Inyo, in consultation with the Department of the California Highway Patrol, the Department of Transportation, and the Department of Parks and Recreation, to prepare and submit to the Legislature a report evaluating the effectiveness of the pilot project by January 1, 2019, as specified. This bill would extend the operation of that pilot project until January 1, 2025, and would require the County of Inyo, in consultation with the above-mentioned entities, to submit an additional evaluation report to the Legislature by January 1, 2024.

SB 410 **(Nielsen R) Hunting and fishing guides.**
Introduced: 2/20/2019
Status: 4/26/2019-Failed Deadline pursuant to Rule 61(a)(2). (Last location was N.R. & W. on 2/28/2019)(May be acted upon Jan 2020)

Location: 4/26/2019-S. 2 YEAR
Summary: Currentlaw requires a person who engages in the business of guiding or packing, or who acts as a guide for any consideration or compensation, to first obtain a guide license from the Department of Fish and Wildlife before engaging in those activities. Current law requires an application for a guide license to contain specified information and requires an applicant to submit proof of having obtained a surety bond in the amount of not less than $1,000 as a condition of receiving a license. Under current law, a guide license is valid from February 1 to January 31 of the succeeding year or, if issued after February 1, for the remainder of the license year. This bill would change the valid period of a guide license to the period of a calendar year, as provided, and would make related conforming changes.

SB 416 **(Hueso D) Employment: workers' compensation.**
Introduced: 2/20/2019
Last Amend: 9/5/2019
Status: 9/15/2019-Failed Deadline pursuant to Rule 61(a)(15). (Last location was DESK on 9/13/2019)(May be acted upon Jan 2020)
Location: 9/15/2019-A. 2 YEAR
Summary: Current law establishes a workers' compensation system to compensate employees for injuries sustained arising out of and in the course of their employment. Existing law designates illnesses and conditions that constitute a compensable injury for various employees, such as members of the Department of the California Highway Patrol, firefighters, and certain peace officers. These injuries include, but are not limited to, hernia, pneumonia, heart trouble, cancer, meningitis, and exposure to biochemical substances, when the illness or condition develops or manifests itself during a period when the officer or employee is in service of the employer, as specified. Would expand the coverage of the above provisions relating to compensable injuries to include all persons defined as peace officers under certain provisions of law, except as specified. This bill contains other related provisions and other existing laws.

SB 474 **(Stern D) The California Wildlife Protection Act of 1990: Habitat Conservation Fund.**
Introduced: 2/21/2019
Last Amend: 5/21/2019
Status: 7/10/2019-Failed Deadline pursuant to Rule 61(a)(10). (Last location was W.,P. & W. on 6/6/2019)(May be acted upon Jan 2020)
Location: 7/10/2019-A. 2 YEAR
Summary: Would establish the Wildlife Protection Subaccount in the Habitat Conservation Fund and would require the Controller, if an appropriation is made for this purpose in any fiscal year, to transfer $30,000,000 from the General Fund to the subaccount, less any amount transferred from specified accounts and funds, to be expended by the board for the acquisition, enhancement, or restoration of wildlife habitat.

SB 518 **(Wieckowski D) Civil actions: settlement offers.**
Introduced: 2/21/2019
Last Amend: 6/20/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Current law, in a civil action to be resolved by trial or arbitration, authorizes a party to serve an offer in writing on any other party to the action to allow judgment to be taken or an award to be entered in accordance with the terms and conditions stated at the time. Existing law shifts specified postoffer costs to a plaintiff who does not accept a defendant's offer if the plaintiff fails to obtain a more favorable judgment or award. Current law also authorizes a court or arbitrator to order a party who does not accept the opposing party's offer and fails to obtain a more favorable judgment or award to cover the postoffer costs for the services of expert witnesses, as specified. Current law exempts certain actions from those provisions, including any labor arbitration filed pursuant to a memorandum

of understanding under the Ralph C. Dills Act. This bill would also exempt from those provisions any action to enforce the California Public Records Act.

SB 542 **(Stern D) Workers' compensation.**
Introduced: 2/22/2019
Last Amend: 9/6/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Under current law, a person injured in the course of employment is generally entitled to receive workers' compensation on account of that injury. Current law provides that, in the case of certain state and local firefighting personnel and peace officers, the term "injury" includes various medical conditions that are developed or manifested during a period while the member is in the service of the department or unit, and establishes a disputable presumption in this regard. This bill would provide, only until January 1, 2025, that in the case of certain state and local firefighting personnel and peace officers, the term "injury" also includes post-traumatic stress that develops or manifests itself during a period in which the injured person is in the service of the department or unit. The bill would apply to injuries occurring on or after January 1, 2020.

SB 566 **(Borgeas R) Fish and Game Commission.**
Introduced: 2/22/2019
Status: 3/7/2019-Referred to Com. on RLS.
Location: 2/22/2019-S. RLS.
Summary: The California Constitution establishes the 5-member Fish and Game Commission, with members appointed by the Governor and approved by the Senate. Current statutory law states the intent of the Legislature to encourage the Governor and the Senate Committee on Rules to consider certain minimum qualifications in selecting, appointing, and confirming commissioners to serve on the commission. This bill would make a nonsubstantive change to this provision.

SB 587 **(Monning D) California Sea Otter Fund.**
Introduced: 2/22/2019
Last Amend: 8/12/2019
Status: 8/12/2019-From committee with author's amendments. Read second time and amended. Re-referred to Com. on RLS.
Location: 2/22/2019-S. RLS.
Summary: Current law, until January 1, 2021, establishes the California Sea Otter Fund and allows individuals to designate on their personal income tax returns that a specified amount in excess of their tax liability be transferred to the fund. Current law requires money in that fund, upon appropriation by the Legislature, to be allocated to the Department of Fish and Wildlife for the purposes of establishing a sea otter fund to be used for sea otter conservation, and to the State Coastal Conservancy for competitive grants and contracts for research, projects, and programs related to the Federal Sea Otter Recovery Plan or improving the nearshore ocean ecosystem. This bill would extend the operation of these provisions to January 1, 2026.

SB 632 **(Galgiani D) California Environmental Quality Act: State Board of Forestry and Fire Protection: vegetation treatment program: final program environmental impact report.**
Introduced: 2/22/2019
Last Amend: 7/11/2019
Status: 9/10/2019-Enrolled and presented to the Governor at 4 p.m.
Location: 9/10/2019-S. ENROLLED
Summary: Current law establishes the State Board of Forestry and Fire Protection and vests the board with authority over wildland forest resources. This bill would require the board, as soon as practicably feasible, but by no later than February 1, 2020, to complete its environmental review under CEQA and certify a specific final program environmental impact report for a vegetation treatment program. The bill would repeal these provisions on January 1, 2021.

SB 744 **(Caballero D) Planning and zoning: California Environmental Quality Act: permanent supportive housing.**
Introduced: 2/22/2019
Last Amend: 7/11/2019
Status: 9/26/2019-Approved by the Governor. Chaptered by Secretary of State. Chapter 346, Statutes of 2019.
Location: 9/26/2019-S. CHAPTERED
Summary: CEQA requires a lead agency to prepare a mitigated negative declaration for a project that may have a significant effect on the environment if revisions in the project would avoid or mitigate that effect and there is no substantial evidence that the project, as revised, would have a significant effect on the environment. Current law authorizes the court, upon the motion of a party, to award attorney's fees to a prevailing party in an action that has resulted in the enforcement of an important right affecting the public interest if 3 conditions are met. This bill would specify that a decision of a public agency to seek funding from, or the department's awarding of funds pursuant to, the No Place Like Home Program is not a project for purposes of CEQA.

SB 757 **(Allen D) Fish and Game Code: name change.**
Introduced: 2/22/2019
Status: 3/14/2019-Referred to Com. on RLS.
Location: 2/22/2019-S. RLS.
Summary: Current law establishes the Fish and Game Code.This bill would rename the Fish and Game Code as the Fish and Wildlife Code and would require that any reference to the Fish and Game Code in that code or any other code means the Fish and Wildlife Code.

SB 761 **(Jones R) Forestry: exemptions: emergency notices: reporting.**
Introduced: 2/22/2019
Status: 3/14/2019-Referred to Com. on RLS.
Location: 2/22/2019-S. RLS.
Summary: Current law authorizes a registered professional forester in an emergency to file, on behalf of a timber owner or operator, a specified emergency notice with the department that allows for the immediate commencement of timber operations. Current law requires the Department of Forestry and Fire Protection and State Board of Forestry and Fire Protection, in consultation with the Department of Fish and Wildlife and the State Water Resources Control Board, commencing December 31, 2019, and annually thereafter, to review and submit a report to the Legislature on the trends in the use of, compliance with, and effectiveness of, these exemptions and emergency notice provisions, as specified. This bill would make nonsubstantive changes in that reporting requirement.

SB 785 **(Committee on Natural Resources and Water) Public resources: parklands, freshwater resources, and coastal resources: off-highway motor vehicles: public lands.**
Introduced: 3/11/2019
Last Amend: 9/3/2019
Status: 9/19/2019-Enrolled and presented to the Governor at 3 p.m.
Location: 9/19/2019-S. ENROLLED
Summary: Current law, until January 1, 2020, generally prohibits a person from possessing, importing, shipping, or transporting in the state, or from placing, planting, or causing to be placed or planted in any water within the state, dreissenid mussels, and authorizes the Director of Fish and Wildlife or the director's designee to engage in various enforcement activities with regard to dreissenid mussels. Among those activities, current law authorizes the director to conduct inspections of waters of the state and facilities located within waters of the state that may contain dreissenid mussels and, if those mussels are detected or may be present, order the closure of the affected waters or facilities to conveyances or otherwise restrict access to the affected waters or facilities, with the concurrence of the Secretary of the Natural Resources Agency. This bill would extend to January 1, 2030, the repeal date of those provisions.

For more information call:

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You can also find legislative information on the web at http://leginfo.legislature.ca.gov/ and follow the prompts from the 'bill information' link.

SB-54 Solid waste: packaging and products. (2019-2020)

SECTION 1. *Section 23671 of the Business and Professions Code is amended to read:*

23671. *(a)* No beer importer shall purchase any beer not manufactured within the state or cause any beer to be transported into the state for sale in the state, unless the out-of-state vendor making shipment of the beer into the state holds a certificate of compliance issued by the department. A certificate of compliance shall be granted when the out-of-state vendor makes a written agreement with the department to furnish to the board, on or before the 10th day of each month, a report on a form prescribed by the board, showing the quantity of beer shipped by the out-of-state vendor to each licensed beer importer in this state during the preceding month. The out-of-state vendor shall further agree that it and its agents and all agencies within this state controlled by it will comply with all laws of this state and all rules of the department with respect to the sale of alcoholic beverages, including, but not limited to, Chapter 12 (commencing with Section 25000) of Division 9, and Section 25509, to the same extent as licensees.

(b) If any out-of-state vendor, after obtaining the certificate, fails to submit the ~~report or~~ *report, fails* to comply with Section 14575 of the Public Resources Code, ~~the~~ *or fails to comply with the provisions of Chapter 3 (commencing with Section 42040) of Part 3 of Division 30 of the Public Resources Code, the* department may suspend or revoke the certificate of compliance in the manner provided for the suspension or revocation of licenses, and after a hearing which shall be held in the City of Sacramento or in any other county seat in this state which the department determines to be convenient to the holder of the certificate. No fee shall be charged for the certificate of compliance which shall remain in effect until revoked by the department.

SEC. 2. *Chapter 3 (commencing with Section 42040) is added to Part 3 of Division 30 of the Public Resources Code, to read:*

CHAPTER 3. California Circular Economy and Pollution Reduction Act

Article 1. General Provisions

42040. *This chapter shall be known, and may be cited, as the California Circular Economy and Pollution Reduction Act.*

42041. *(a) The Legislature finds and declares all of the following:*

(1) Annual global production of plastic has reached 335 million tons and continues to rise. The United States alone discards 30 million tons each year. Global plastic production is projected to more than triple by 2050, accounting for 20 percent of all fossil fuel consumption.

(2) Without action, projections estimate that by 2050 the mass of plastic pollution in the ocean will exceed the mass of fish. A study by the University of Exeter and Plymouth Marine Laboratory in the United Kingdom found plastics in the gut of every single sea turtle examined and in 90 percent of seabirds. Additionally, plastic negatively affects marine ecosystems and wildlife, as demonstrated by countless seabirds, turtles, and marine mammals, including, but not limited to, whales and dolphins, dying from plastic ingestion or entanglement.

(3) Based on data from the United States Environmental Protection Agency, Institute of Scrap Recycling Industries trade statistics, and industry news source Resource Recycling, the national recycling rate for plastic is projected to sink from 9.1 percent in 2015 to 4.4 percent in 2018, and could drop to 2.9 percent in 2019. Even in California, less than 15 percent of single-use plastic is recycled.

(4) Before 2017, the United States was sending 4,000 shipping containers a day full of American waste to China every year, including two-thirds of California's recyclable materials. However, China has implemented the Green Fence, National Sword, and Blue Sky policies, severely restricting the amount of contaminated and poorly sorted plastics it would accept. This shift in China's policy has resulted in the loss of markets for low-value plastic packaging that was previously considered recyclable. That material is now being landfilled or burned.

(5) Additionally, the foreign market for recycled paper has collapsed in California. Foreign exports of mixed paper fell from over 400,000 tons in the first quarter of 2017 to just 136,000 tons in the first quarter of 2018. The price of mixed paper fell from ninety-five dollars ($95) per ton to just ten dollars ($10) a ton in the same timeframe.

(6) The loss of markets for recyclable material has added huge costs to local governments for the disposal and diversion of material. For many cities, counties, and waste haulers in California, recycling has turned from a profitable business into an activity that actually costs local governments money. These costs are being absorbed by city general funds or by rate increases on residents for waste collection.

(7) The environmental and public health impacts of plastic pollution are devastating and the environmental externalities and public costs of cleaning up and mitigating plastic pollution are already staggering and continue to grow.

(8) Local governments in California annually spend in excess of four hundred twenty million dollars ($420,000,000) in ongoing efforts to clean up and prevent plastic and other litter from entering our rivers and streams and polluting our beaches and oceans.

(9) Evidence now shows that even our own food and drinking water sources are contaminated with plastic. Microplastics have been found in tap water, bottled water, table salt, and fish and shellfish from local California fish markets. A growing body of research is finding plastic and associated toxins throughout the food web, including in our blood, feces, and tissues. Exposure to these toxins has been linked to cancers, birth defects, impaired immunity, endocrine disruption, and other ailments.

(10) It is the policy goal of the state that not less than 75 percent of solid waste generated be source reduced, recycled, or composted by the year 2020. However, as of 2017, the state was only on track to reach 44 percent, falling far short of this important goal. Additionally, the state has done little to require businesses to reduce the amount of packaging and single-use product waste they generate in California.

(11) As the fifth largest economy in the world, California has a responsibility to lead on solutions to the growing plastic pollution crisis, and to lead in the reduction of unnecessary waste generally.

(12) Further, businesses selling products into California have a responsibility to ensure that their packaging and products are minimizing waste, including ensuring materials used are reusable, recyclable, or compostable. This responsibility includes paying for the cost of the negative externality of recovery for materials they sell in California.

(b) (1) Consistent with the policy goal established in Section 41780.01, it is the intent of the Legislature that, by 2030, producers of single-use products that are not priority single-use products achieve and maintain a statewide 75-percent reduction of the waste generated from single-use products offered for sale, sold, distributed, or imported in or into the state that are not priority single-use products through source reduction, recycling, or composting.

(2) In accordance with paragraph (1), it is the intent of the Legislature that producers of single-use products that are not priority single-use products do all of the following for single-use products that are not priority single-use products:

(A) Source reduce those products, and transition those products to reusable products, to the maximum extent feasible.

(B) Ensure those products are recyclable or compostable, as determined by the department pursuant to Section 42052.

(C) For single-use plastic products that are not priority single-use products and that are offered for sale, sold, distributed, or imported in or into California, reduce waste generation by 75 percent through combined source reduction and recycling.

(c) It is the intent of the Legislature that any deposit-based mechanism identified pursuant to clause (ii) of subparagraph (B) of paragraph (2) of subdivision (b) of Section 42050 or implemented as a corrective action pursuant to paragraph (2) of subdivision (a) of Section 42061 ensures that consumers can conveniently receive a refund for returning single-use packaging or priority single-use products.

***42042.** (a) For purposes of this chapter, all of the following shall apply:*

(1) "California circular economy regulatory fee" means the fee imposed by the department pursuant to Section 42080.

(2) “Packaging” means the material used for the containment, protection, handling, delivery, or presentation of goods by the producer for the user or consumer, ranging from raw materials to processed goods. Packaging includes, but is not limited to, all of the following:

(A) Sales packaging or primary packaging intended to constitute a sales unit to the consumer at point of purchase and most closely contains the product, food, or beverage.

(B) Grouped packaging or secondary packaging intended to brand or display the product.

(C) Transport packaging or tertiary packaging intended to protect the product during transport.

(3) “Packaging category” means a packaging material category on the list published by the department pursuant to subdivision (c) of Section 42054.

(4) “Priority single-use products” means single-use food service ware, including plates, bowls, cups, utensils, stirrers, and straws.

(5) “Product category” means a priority single-use product material category on the list published by the department pursuant to subdivision (c) of Section 42054.

(6) (A) “Producer” means the person who manufactures the single-use packaging or priority single-use product under that person’s own name or brand and who sells or offers for sale the single-use packaging or priority single-use product in the state.

(B) If there is no person who is the producer of the single-use packaging or priority single-use products for purposes of subparagraph (A), the producer is the person who imports the single-use packaging or priority single-use product as the owner or licensee of a trademark or brand under which the single-use packaging or priority single-use product is sold or distributed in the state.

(C) If there is no person who is the producer for purposes of subparagraphs (A) and (B), the producer is the person or company that offers for sale, sells, or distributes the single-use packaging or priority single-use product in the state.

(D) Notwithstanding subparagraphs (A) to (C), inclusive, for beer and malt beverages manufactured outside of the state “producer” means the person named on the certificate of compliance issued pursuant to Section 23671 of the Business and Professions Code.

(7) “Retailer or wholesaler” means the person who sells the single-use packaging, product packaged in single-use packaging, or priority single-use product in the state or offers to consumers the single-use packaging, product packaged in single-use packaging, or priority single-use product in the state through any means, including, but not limited to, any of the following:

(A) Remote offering, including sales outlets or catalogs.

(B) Electronically through the internet.

(C) Telephone.

(D) Mail.

(8) (A) “Single-use packaging” means the packaging of a product when the packaging is routinely recycled, disposed of, or discarded after its contents have been used or unpackaged, and typically not refilled by the producer.

(B) Single-use packaging does not include any of the following:

(i) Reusable packaging, as determined by the department pursuant to Section 42052.

(ii) Packaging containing toxic or hazardous products regulated by the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 136 et seq.).

(iii) Plastic packaging containers that are manufactured for use in the shipment of hazardous materials and are prohibited from being manufactured with used material by federal packaging material specifications set forth in Sections 178.509 and 178.522 of Title 49 of the Code of Federal Regulations.

(iv) Until January 1, 2026, beverage containers subject to the California Beverage Container Recycling and Litter Reduction Act (Division 12.1 (commencing with Section 14500)).

(9) "Source reduction" includes, but is not limited to, transitioning single-use packaging or a priority single-use product to refillable or reusable packaging or a reusable product. Source reduction does not include replacing a recyclable or compostable material with a nonrecyclable or noncompostable material or a material that is less likely to be recycled or composted, and does not include a shift from a nonplastic material that currently is recyclable or compostable to plastic material.

(10) "Unexpended funds" means money in a stewardship organization's accounts that the stewardship organization is not already obligated to pay pursuant to a contract, claim, or similar mechanism. "Unexpended funds" excludes regulatory fees.

(b) For purposes of this chapter, all of the following shall not be considered single-use packaging or priority single-use products:

(1) Medical products, as well as products defined as medical devices and prescription drugs as specified in the federal Food, Drug, and Cosmetic Act (21 U.S.C. Secs. 321(h) and (g), and Sec. 353(b)(1)).

(2) Drugs that are used for animal medicines, including, but not limited to, parasiticide products for animals.

(3) Infant formula, as defined in Section 321(z) of Title 21 of the United States Code.

(4) Medical food as defined pursuant to Section 360ee(b)(3) of Title 21 of the United States Code.

(5) Fortified oral nutritional supplements used for persons who require supplemental or sole source nutrition to meet nutritional needs due to special dietary needs directly related to cancer, chronic kidney disease, diabetes, or other medical conditions as determined by the department.

(6) Packaging used for a product listed in paragraphs (1) to (5), inclusive.

Article 2. Single-use Packaging and Priority Single-use Products

***42050.** (a) Before January 1, 2024, the department shall, in consultation with relevant state agencies with jurisdiction relevant to this chapter and local jurisdictions and regional agencies charged with meeting waste diversion goals, adopt regulations that do all of the following:*

(1) (A) Require producers of single-use packaging to source reduce single-use packaging to the maximum extent feasible.

(B) Require producers of single-use packaging to ensure that all single-use packaging manufactured on or after January 1, 2030, and that is offered for sale, sold, distributed, or imported in or into California is recyclable or compostable as determined by the department pursuant to Section 42052.

(2) (A) Require producers of priority single-use products to source reduce priority single-use products to the maximum extent feasible.

(B) Require producers of priority single-use products to ensure that priority single-use products manufactured on or after January 1, 2030, and that are offered for sale, sold, distributed, or imported in or into California are recyclable or compostable as determined by the department pursuant to Section 42052.

(3) Achieve and maintain, by January 1, 2030, through the regulations adopted by the department and implemented by producers pursuant to this chapter, a statewide 75-percent reduction of the waste generated from single-use packaging and priority single-use products offered for sale, sold, distributed, or imported in or into the state through source reduction, recycling, or composting.

(4) Require producers to comply with the requirements of this chapter and its implementing regulations.

(b) (1) By January 1, 2023, and before adopting the regulations, in order to increase the opportunity for public participation and to receive comments, the department shall finalize an implementation plan for meeting the requirements of this chapter.

(2) As part of the implementation plan, the department shall do all of the following:

(A) Conduct extensive outreach to stakeholders and to state and local agencies with jurisdiction relevant to this chapter, including, but not limited to, the state's waste diversion, climate, water quality, public health, and air quality goals, and the state's toxic substances regulation. This outreach shall include, but is not limited to, convening a series of public workshops throughout the state to give interested parties an opportunity to comment and a series of stakeholder meetings designed to facilitate dialogue between stakeholders representing different interest groups such as local governments, the solid waste and recycling industries, product and packaging

manufacturers, retailers and wholesalers, trade associations, and environmental organizations. These meetings shall be held throughout the state to increase the opportunity for participation and shall inform the development of regulations pursuant to this section.

(B) Evaluate all of the following:

(i) Incentives and policies to maximize and encourage in-state manufacturing using recycled material generated in California and the development of reusable packaging and products.

(ii) Economic mechanisms to reduce the distribution of single-use packaging and priority single-use products or to transition single-use packaging and priority single-use products to reusable alternatives and increase the recyclability or compostability of single-use packaging and priority single-use products. These economic mechanisms may include, but are not limited to, allowing producers to establish and operate a collection and deposit program, assess a generation-based fee, an advanced recycling fee, pay as you throw fees, or extended producer responsibility for single-use packaging and priority single-use products.

(iii) Avoiding the litter, export, or improper disposal of single-use packaging, priority single-use products, and other materials likely to harm the environment or public health in California or elsewhere in the world.

(iv) Labeling requirements regarding the recyclability, compostability, or reusability of packaging and priority single-use products. Labeling requirements may include criteria for packaging to be labeled "recyclable," "compostable," "reusable," or "refillable" based on factors including, but not limited to, whether the packaging or product can be readily recycled, composted, or reused and whether the packaging or product is likely to contaminate other recyclable or compostable material or complicate processing. In developing labeling requirements, the department shall consider national and international labeling standards and systems.

(v) Possible options for producers to implement the requirements of this chapter and reduce packaging and product waste, including, but not limited to, through implementation of effective and convenient take-back opportunities, deposit systems, reusable and refillable delivery systems, designing for recyclability or compostability, advanced disposal fees, incentive programs, or similar mechanisms. The department may allow producers to implement extended producer responsibility programs, where appropriate, consistent with the requirements of Article 4 (commencing with Section 42070).

(vi) Actions identified through the California Ocean Litter Prevention Strategy and the Statewide Microplastics Strategy.

(vii) Establishing criteria for the source reduction requirements specified in subdivision (a) and to inform the checklist specified in paragraph (3) of subdivision (h). Consideration shall include reducing weight, volume, or quantity of single-use packaging and priority single-use product material in a way that does not decrease the ability of the material to be recycled or reused.

(viii) Establishing minimum postconsumer recycled content requirements for a packaging or product category, where appropriate, in order to create or enhance markets for recycled material.

(ix) How to address technological innovations and new packaging materials or categories.

(C) Consider and provide recommendations on whether to transition or sunset existing recycling programs.

(D) Identify all of the following:

(i) Opportunities to improve and expand waste collection and processing capabilities and infrastructure, including the use of innovative new recycling and reuse technologies and secondary material recovery facilities.

(ii) Opportunities to harmonize local waste, recycling, and composting programs among local jurisdictions and barriers to cooperation and standardization of programs.

(iii) Opportunities for encouraging the use of reusable or refillable packaging.

(iv) Opportunities for public education efforts to increase recycling and composting of single-use packaging and priority single-use products and reducing litter from these items.

(v) Potential end-use markets for collected materials and policies required to stimulate domestic markets.

(vi) Opportunities for incentivizing and increasing consumer recycling.

(vii) Discussion for identifying and conducting outreach to producers.

(c) (1) The department may identify single-use packaging or priority single-use products that, while determined to be single use for purposes of this chapter, present unique challenges in complying with this chapter.

(2) For any packaging or products identified as presenting unique challenges, the department may at any point develop a plan to phase the packaging or products into the regulations.

(d) The department shall ensure that any regulations adopted pursuant to this chapter account for guidelines and regulations issued by the United States Food and Drug Administration.

(e) If the department determines at any point a type of single-use packaging or priority single-use product cannot comply with this chapter due to health and safety reasons, or because it is unsafe to recycle, the department may exempt that packaging or product from this chapter.

(f) The regulations shall establish a baseline for the 75-percent waste reduction requirement in subdivision (a) for each packaging and product category based on waste characterization studies undertaken by the department, and any other information received by the department.

(g) (1) Producers shall do both of the following:

(A) Register with the department.

(B) Report any data to the department that the department deems necessary to determine compliance with this chapter in a form, manner, and frequency determined by the department.

(2) Any confidential or proprietary market sensitive data received by the department pursuant to this chapter shall be held confidentially by the department as required by Section 40062 and any implementing regulations.

(3) The department shall create an online registration form to facilitate submitting reports pursuant to this subdivision.

(4) Producers shall submit the information required by the department pursuant to paragraph (1) using the format established by the department pursuant to paragraph (3).

(5) The department's regulations shall establish appropriate timelines to begin reporting following the adoption of regulations. The department shall consider the amount of information being reported in developing the timelines.

(h) (1) The department's regulations shall include direct source reductions of single-use packaging and priority single-use products to the maximum extent feasible, in accordance with this section.

(2) The department may consider single-use packaging and priority single-use product reductions achieved by a producer before the effective date of the regulations if the producer can demonstrate to the satisfaction of the department that the producer reduced the single-use packaging or priority single-use product in a manner consistent with this chapter.

(3) (A) The department shall develop a checklist of source reduction measures, and a producer that complies with all applicable measures on the checklist shall be in compliance with the requirement to source reduce to the maximum extent feasible pursuant to subdivision (a). The department shall also offer guidance on how to use the checklist as a means of complying with subdivision (a). The checklist measures may include, but are not limited to, ensuring the single-use packaging or priority single-use product remains recyclable or compostable, right-sizing products, eliminating excess packaging, compliance with internal or third-party certified packaging design guidelines, concentrating a product to reduce packaging, and transitioning to reusable alternatives where those alternatives are readily available.

(B) To determine which source reduction measures to include in the checklist, the department shall consider which single-use packaging and priority single-use products are prone to become litter, have readily available alternatives, make up a significant portion of the waste stream, or have established, or have the potential for, recycling or composting infrastructure.

(C) The checklist shall incorporate considerations that assist the department in evaluating whether it is feasible for a producer to implement one or more of the checklist source reduction measures, including product protection and integrity, consumer safety, shelf life, compatibility with distribution systems, and other relevant factors as the department deems appropriate.

(4) When establishing the source reduction measures, the department shall avoid incentivizing substitutions that may have a more substantial negative impact on the environment.

(5) In developing the regulations, the department shall count a producer's source reductions achieved to comply with Chapter 5.5 (commencing with Section 42300) toward compliance with this chapter.

(6) If the department believes a producer has not met its obligation to source reduce to the maximum extent feasible, or if the department believes additional source reduction is feasible when the producer believes it is not, then the producer shall be given an opportunity to explain any relevant factors that would limit its ability to meet its obligation or implement additional source reduction measures.

(i) If the department determines that early actions to source reduce certain single-use packaging and priority single-use products can further the purposes of this chapter, the department may adopt regulations to achieve those reductions. If the department adopts regulations pursuant to this subdivision, the department shall report that action to the Legislature in the next report submitted pursuant to Section 42060.

(j) In developing the regulations, the department shall consider relevant information on reduction programs and approaches in other states, localities, and nations, including, but not limited to, the European Union, India, Costa Rica, and Canada, and international standards, including, but not limited to, ISO 18602.

(k) The department may determine which actions producers may undertake to achieve the requirements of subdivision (a) based on packaging or product category.

(l) In adopting regulations pursuant to this section, the department shall consider and avoid disproportionate impacts to low-income or disadvantaged communities.

(m) The department shall not impose a recycled content requirement or any other requirement in direct conflict with a federal law or regulation, including, but not limited to, laws or regulations covering tamper-evident packaging pursuant to Section 211.132 of Title 21 of the Code of Federal Regulations, laws or regulations covering child-resistant packaging pursuant to Part 1700 of Subchapter E of Chapter II of Title 16 of the Code of Federal Regulations, or requirements for microbial contamination, structural integrity, or safety of packaging under the federal Food, Drug, and Cosmetic Act (21 U.S.C. Sec. 301 et seq.), 21 U.S.C. Sec. 2101 et seq., the federal FDA Food Safety Modernization Act (21 U.S.C. Sec. 2201 et seq.), or the regulations, rules, or guidance issued pursuant to those laws.

(n) The department shall develop criteria for exemptions from the requirements of this chapter for small producers, retailers, and wholesalers.

(o) The department shall establish criteria for allowing producers to comply with the requirements of this chapter through contractual arrangements with third parties that do not otherwise meet the definition of producer in subparagraph (A) of paragraph (6) of subdivision (a) of Section 42042. The criteria shall not limit the department's ability to enforce or otherwise implement this chapter.

42051. *(a) The department may adopt emergency regulations to implement and enforce all of the following:*

(1) Subdivision (g) of Section 42050.

(2) Subdivision (i) of Section 42050.

(3) Subdivisions (c) and (d) of Section 42054.

(4) Section 42055.

(5) Section 42080.

(b) Emergency regulations adopted pursuant to this section shall be adopted in accordance with Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code, and for the purposes of that chapter, including Section 11349.6 of the Government Code, the adoption of these regulations is an emergency and shall be considered by the Office of Administrative Law as necessary for the immediate preservation of the public peace, health, safety, and general welfare. Notwithstanding Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code, any emergency regulations adopted by the department pursuant to this section shall be filed with, but not be repealed by, the Office of Administrative Law and shall remain in effect for a period of two years or until revised by the department, whichever occurs sooner.

42052. *(a) In adopting regulations pursuant to Section 42050, the department shall develop criteria to determine whether the packaging or priority single-use products are reusable, recyclable, or compostable.*

(b) (1) For purposes of determining if single-use packaging or priority single-use products are recyclable, the

director shall consider, at a minimum, all of the following criteria:

(A) Whether the single-use packaging or priority single-use product is eligible to be labeled as "recyclable" in accordance with the uniform standards contained in Article 7 (commencing with Section 17580) of Chapter 1 of Part 3 of Division 7 of the Business and Professions Code.

(B) Whether the single-use packaging or priority single-use product is regularly collected, separated, and cleansed for recycling by recycling service providers.

(C) Whether the single-use packaging or priority single-use product is regularly sorted and aggregated into defined streams for recycling processes.

(D) Whether the single-use packaging or priority single-use product is regularly processed and reclaimed or recycled with commercial recycling processes.

(E) Whether the single-use packaging or priority single-use product material regularly becomes feedstock that is used in the production of new products.

(F) Whether the single-use packaging or priority single-use product material is recycled in sufficient quantity, and is of sufficient quality, to maintain a market value.

(2) For purposes of determining if single-use packaging or priority single-use products are recyclable, the director shall consider the regulations adopted pursuant to Article 10.4 (commencing with Section 25214.11) of Chapter 6.5 of Division 20 of the Health and Safety Code.

(3) For purposes of determining if single-use packaging or priority single-use products are recyclable, de minimis amounts of nonrecyclable material of more than 3 percent of the total weight or volume of the single-use packaging or priority single-use product material is acceptable when the nonrecyclable material is required for the proper delivery, safety, sterility, stability, or use of the product or the product contained within the packaging. If the nonrecyclable material negatively affects the recyclability of the product or packaging, the material shall not be considered de minimis.

(c) For purposes of determining if single-use packaging or priority single-use products are compostable, the director shall consider, at a minimum, all of the following criteria:

(1) Whether the single-use packaging or priority single-use product will, in a safe and timely manner, break down or otherwise become part of usable compost that can be composted in a public or private compost facility designed for and capable of processing postconsumer food waste and food-soiled paper.

(2) Whether the single-use packaging or priority single-use product made from plastic is certified to meet the ASTM standard specification identified in either subparagraph (A) or (C) of paragraph (1) of subdivision (b) of Section 42356 and adopted in accordance with Section 42356.1, if applicable.

(3) Whether the single-use packaging or priority single-use product is regularly collected and accepted for processing at public and private compost facilities.

(4) Whether the single-use packaging or priority single-use product is eligible to be labeled as "compostable" in accordance with the uniform standards contained in Article 7 (commencing with Section 17580) of Chapter 1 of Part 3 of Division 7 of the Business and Professions Code.

(d) For purposes of determining if packaging or a priority single-use product is reusable, the department shall consider, at a minimum, both of the following criteria:

(1) Whether the packaging or priority single-use product is conventionally disposed of after a single use.

(2) Whether the packaging or priority single-use product is sufficiently durable, washable, and intended for multiple refills of the original product to allow for multiple uses.

(e) (1) In implementing this section, the department may consult with local governments and representatives of the solid waste industry, the recycling industry, the reuse industry, the compost industry, and single-use product and packaging manufacturers to determine if a type of packaging or priority single-use product is recyclable, reusable, or compostable.

(2) Local governments, solid waste facilities, recycling facilities, and composting facilities may provide information requested by the department pursuant to paragraph (1) to the department.

42053. *(a) In implementing this chapter, the department shall establish a Circular Economy and Waste Pollution Reduction Panel for the purpose of identifying barriers and solutions to creating a circular economy consistent with this chapter. The panel shall be composed of one or more members from each of the following disciplines, with equal representation from each discipline:*

(1) Local government.

(2) Waste management.

(3) Environmental health or sustainability.

(4) Product or packaging manufacturing.

(5) Product or packaging design.

(6) Recyclers.

(b) The department shall appoint all members to the panel on or before January 1, 2021. The department shall appoint the members for staggered three-year terms, and may reappoint a member for additional terms, without limitation.

(c) The panel shall meet as often as the department deems necessary, with consideration of available resources, but not less than twice each year. The department shall provide for staff and administrative support to the panel.

(d) The panel meetings shall be open to the public and are subject to the Bagley-Keene Open Meeting Act (Article 9 (commencing with Section 11120) of Chapter 1 of Part 1 of Division 3 of Title 2 of the Government Code).

(e) The panel shall provide the department with initial recommendations regarding key barriers and possible solutions to advance the objectives of increasing recovery of packaging and product materials and decreasing the leakage of plastic into the environment no later than one year after the panel's initial meeting. The department shall consider these recommendations as it evaluates what specific actions may be appropriate to advance the objectives of this chapter.

(f) The panel may take any of the following actions through written recommendations as the panel deems appropriate:

(1) Advise the department on technical matters in support of the goals of this chapter to create a circular economy and reduce product and packaging pollution.

(2) Advise the department in the adoption of the implementation plan and regulations required by this chapter.

(3) Advise the department on any other pertinent matter in implementing this chapter, as determined by the panel or department.

(g) The panel shall submit written recommendations to the department only if a majority or more of the panel's members endorse the recommendation. One or more panel members that do not endorse the recommendation may submit a separate written recommendation to the department reflecting the minority opinion or opinions.

42054. *(a) Single-use packaging and priority single-use products offered for sale, sold, distributed, or imported in or into California by a producer shall meet the following recycling rates:*

(1) On and after January 1, 2026, not less than 30 percent for single-use packaging and priority single-use products manufactured on or after January 1, 2026.

(2) On and after January 1, 2028, not less than 40 percent for single-use packaging and priority single-use products manufactured on or after January 1, 2028.

(3) On and after January 1, 2030, not less than 75 percent for single-use packaging and priority single-use products manufactured on or after January 1, 2030.

(b) (1) Notwithstanding subdivision (a), the department may, subject to paragraph (3), impose a higher or lower recycling rate for single-use packaging or priority single-use products as needed to achieve the requirements established in Section 42050.

(2) Commencing in 2024, and every two years thereafter, the department shall review, in consultation with the panel created pursuant to Section 42053, relevant data to assess whether the recycling rate required in subdivision (a) should be adjusted. The department shall make its determination and rationale available for public

review.

(3) If the department determines pursuant to a review under paragraph (2) that current unforeseen and anomalous market conditions, including, but not limited to, recycling infrastructure conditions, warrant an adjustment to the recycling rates required in subdivision (a), the department may impose a higher or lower recycling rate subject to the following conditions:

(A) The recycling rate shall not be adjusted by more than 10 percent of what is required in subdivision (a).

(B) The adjusted recycling rate shall be in effect for no more than two years.

(c) (1) Before adopting the implementation plan or regulations, the department shall establish and post on its internet website a list of packaging and product categories of single-use packaging and priority single-use products.

(2) The department may consider material types and form referenced in waste characterization studies for determining the packaging and product categories.

(d) (1) The department shall calculate and publish on its internet website the recycling rates for each packaging and product category no later than January 1, 2025. These recycling rates shall be deemed to meet the description in subdivision (g) of Section 11340.9 of the Government Code and may be filed by the department pursuant to Section 11343.8 of the Government Code.

(2) In determining a recycling rate, the department may consider data gathered pursuant to any of the following:

(A) Chapter 746 of the Statutes of 2015.

(B) Chapter 6 (commencing with Section 42370).

(C) Chapter 395 of the Statutes of 2016.

(D) Chapter 5.5 (commencing with Section 42300).

(E) Division 12.1 (commencing with Section 14500).

(F) Data voluntarily provided by local jurisdictions.

(G) Data and information received from producers.

(H) Any other relevant data and information received by the department.

(3) The department shall determine and post on its internet website whether each packaging and product category recycling rate complies with the recycling rates required pursuant to this section.

(4) For purposes of determining the recycling rate, the department shall include single-use packaging and priority single-use products that are recycled or composted.

(5) A producer may demonstrate compliance with subdivision (a) or (b) by submitting to the department evidence that the particular type of single-use packaging or priority single-use product meets the applicable recycling rate threshold established in subdivision (a) or (b) by reference to a recycling rate on the department's list or through another mechanism approved by the department.

(6) The department shall update the list at least every two years and shall regularly, but no less than once every two years, evaluate the list of recycling rates to determine whether the recycling rates are still accurate. After evaluation, the department may amend the list to remove, add, or change recycling rates. The department shall post any updates to the list on its internet website.

(7) A producer that seeks to have a recycling rate included or changed on the list, or a packaging or product category added to the list, may be required by the department to submit data for purposes of the department's determination of the recycling rate to include on the list.

(8) Development of, publication of, and updates made to the list pursuant to this subdivision are exempt from Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code.

42054.1. *The department shall post on its internet website a list of compliant producers that are in compliance with this chapter and a list of noncompliant producers that are not in compliance with this chapter. The department shall update the list at least once every six months.*

42055. *(a) A retailer and wholesaler shall register with the department and do both of the following:*
(1) Report to the department the producers that provide the retailer or wholesaler with single-use packaging, products packaged in single-use packaging, or priority single-use products.

(2) Not offer for sale or sell single-use packaging, a product packaged in single-use packaging, or a priority single-use product if the producer of the single-use packaging or priority single-use product is listed as noncompliant on the department's internet website pursuant to Section 42054.1.

(b) The department may require electronic registration and reporting by retailers and wholesalers.

42056. *(a) In complying with this chapter, producers, retailers, and wholesalers shall do all of the following:*

(1) Upon request, provide the department with reasonable and timely access to its facilities and operations, as necessary to determine compliance with this chapter.

(2) Upon request, provide the department with relevant records necessary to determine compliance with this chapter.

(b) Provide required reports and data that are accurate and attested to under penalty of perjury as required by the department.

Article 3. Implementation and Enforcement
42060. *The department shall report to the Legislature in compliance with Section 9795 of the Government Code every three years its progress in implementing this chapter. The implementation plan required by Section 42050 shall constitute a report for the purposes of this section.*

42061. *(a) (1) The department may issue a notice of violation to and impose an administrative civil penalty not to exceed fifty thousand dollars ($50,000) per day per violation on any entity not in compliance with this chapter or any of the regulations the department adopts to implement this chapter.*

(2) Before determining whether or not to assess a penalty, the department may require a producer to develop and submit a corrective action plan to the department detailing how the producer will come into compliance with this chapter. Corrective action plans may include, but are not limited to, actions such as shifting production away from packaging and product categories that do not meet the recycling rates required pursuant to Section 42054, reaching a minimum content standard set by the department, or establishing a take-back system or deposit fee system for single-use packaging or priority single-use products that would increase the recycling rate of the material. The department shall not assess a penalty and the producer shall remain listed as compliant pursuant to Section 42054.1 if the producer complies with the corrective action plan. A producer may request approval from the department to comply with a corrective action plan or elements of a corrective action plan through a joint venture or joint actions with other producers.

(3) The department, in determining the penalty amount and whether or not to assess a penalty, shall consider all of the following:

(A) The nature, circumstances, extent, and gravity of the violation or a condition giving rise to the violation and the various remedies and penalties that are appropriate in the given circumstances, with primary emphasis on protecting the public health and safety and the environment.

(B) Whether the violation or conditions giving rise to the violation have been corrected in a timely fashion or whether reasonable progress is being made to correct the violation or conditions giving rise to the violation.

(C) Whether the violation or conditions giving rise to the violation demonstrate a chronic pattern of noncompliance with this chapter or the regulations adopted pursuant to this chapter.

(D) Whether the violation or conditions giving rise to the violation were intentional.

(E) Whether the violation or conditions giving rise to the violation were voluntarily and promptly reported to the department before the commencement of an investigation or audit by the department.

(F) Whether the violation or conditions giving rise to the violation were due to circumstances beyond the reasonable control of the producer or were otherwise unavoidable under the circumstances, including, but not limited to, unforeseen changes in market conditions.

(G) The size and economic condition of the producer.

(4) (A) The department may extend a previously established timeframe for a producer to comply with a corrective

action plan for up to 24 months if the department sets forth steps for the producer to achieve compliance with the corrective action plan and if the producer has demonstrated that it has made a substantial effort to comply and that there are extenuating circumstances that have prevented it from complying.

(B) For purposes of this paragraph, "substantial effort" means that a producer has taken all practicable actions to comply with a corrective action plan. Substantial effort does not include circumstances in which the decisionmaking body of a producer has not taken the necessary steps to comply with a corrective action plan, including, but not limited to, a failure to provide staff resources or a failure to provide sufficient funding to ensure compliance with a correction action plan.

(b) A producer may offer for sale, sell, distribute, or import single-use packaging or priority single-use products in a packaging or product category that does not meet the recycling rates established pursuant to subdivision (a) or (b) of Section 42054 if the producer demonstrates to the department that the producer has implemented actions to achieve the recycling rates established pursuant to subdivision (a) or (b) of Section 42054 for an amount equal to the producer's market share of that packaging or product category in California.

(c) (1) The department may audit producers, retailers, and wholesalers including, but not limited to, reports submitted by a producer and demonstrations made by a producer pursuant to Section 42054.

(2) The department shall review an audit for compliance with this chapter and consistency with information reported pursuant to this chapter.

(3) The department shall notify a producer, retailer, or wholesaler of any conduct or practice that does not comply with this chapter or of any inconsistencies identified in the department's audit.

(4) A producer, retailer, or wholesaler may obtain copies of the department's audit of the producer upon request.

(5) The department shall not disclose any confidential or proprietary information that is included in the department's audit to the extent that information is protected from disclosure by existing law.

(d) Subdivision (a) does not apply to the requirements of paragraph (1) of subdivision (a) of Section 42054. The department may notify the producer of the failure to comply with the requirements of paragraph (1) of subdivision (a) of Section 42054.

Article 4. Single-use Packaging and Priority Single-use Product Stewardship

42070. *(a) The department may adopt regulations allowing producers to meet the requirements of this chapter collectively by forming a stewardship organization that adopts a stewardship plan in accordance with this article. If the department adopts those regulations, the regulations shall include all of the provisions of this article.*

(b) A producer that is a member of a stewardship organization, which is formed in accordance with this article and is in compliance with this chapter, shall not individually be subject to the requirements of this chapter for the single-use packaging and priority single-use products covered by the stewardship plan, except as specified in a stewardship plan adopted by a stewardship organization in accordance with this article.

(c) In accordance with Section 42080, a stewardship organization formed in accordance with this article shall be responsible for paying the California circular economy regulatory fee on behalf of its members and may require a member to reimburse the stewardship organization for the amount of the regulatory fee paid on behalf of the member.

42071. *(a) Producers may form a stewardship organization exempt from taxation under Section 501(c)(3) of the federal Internal Revenue Code of 1986.*

(b) A stewardship organization formed pursuant to subdivision (a) shall develop and submit to the department a stewardship plan for the source reduction, collection, and recycling of the single-use packaging or priority single-use products that the producers covered under the plan sell, offer for sale, distribute, or import in or into the state in an economically efficient and practical manner. The stewardship plan shall be consistent with the regulations adopted in accordance with Section 42050.

(c) Within 90 days after approval or conditional approval by the department of the plan, the stewardship organization shall implement the approved plan.

(d) The approved plan shall be a public record, except that financial, production, or sales data reported to the department by the stewardship organization is not a public record for purposes of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1 of the Government Code) and shall not be open to public inspection. The department may release financial, production, or sales data in summary form so

the information cannot be attributable to a specific producer, retailer, wholesaler, or to any other entity.

42072. *(a) The stewardship organization shall keep minutes, books, and records that clearly reflect the activities and transactions of the stewardship organization.*

(b) The accounting books of the stewardship organization shall be audited at the stewardship organization's expense by an independent certified public accountant retained by the stewardship organization at least once each calendar year.

(c) The stewardship organization shall arrange for the audit to be delivered to the department with the annual report required pursuant to Section 42073. The department shall review the audit for compliance with this article and consistency with the plan created pursuant to this article. The department shall notify the stewardship organization of any compliance issues or inconsistencies.

(d) The department may conduct its own audit if it determines that an audit is necessary to enforce the requirements of this article and that the audit conducted pursuant to subdivision (b) is not adequate for this purpose. The stewardship organization may obtain copies of the audit upon request.

(e) The department shall not disclose any confidential or proprietary information in an audit.

42073. *The stewardship organization shall annually submit to the department and make publicly available on its internet website an annual report that describes how the organization has complied with the requirements of this chapter and its implementing regulations.*

42074. *(a) The department shall review the annual report for compliance with this article and shall approve, disapprove, or conditionally approve the report within 120 days of receipt of the annual report.*

(b) If the department disapproves the annual report, the department shall explain, in writing, how the annual report does not comply with this article, and the stewardship organization shall resubmit the report with any additional information, modifications, or corrections to the department within 30 days. If the department finds that the annual report resubmitted by the stewardship organization does not comply with the requirements of this article, the stewardship organization shall not be deemed in compliance with this article until the stewardship organization submits an annual report that the department finds compliant with the requirements of this article.

(c) The approved annual report shall be a public record, except that financial, production, or sales data reported to the department by the stewardship organization is not a public record for purposes of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1 of the Government Code) and shall not be open to public inspection. The department may release financial, production, or sales data in summary form so the information cannot be attributable to a specific producer, retailer, wholesaler, or to any other entity.

42075. *(a) A stewardship organization, as part of its stewardship plan, shall set up a trust fund or an escrow account, into which it shall deposit all unexpended funds, for use in accordance with this section in the event that the stewardship plan terminates or is revoked.*

(b) If a stewardship plan terminates or is revoked, the trustee or escrow agent of a trust fund or escrow account set up pursuant to subdivision (a) shall do both of the following, starting within 30 days:

(1) Accept payments directly from producers into the trust fund or escrow account that would have been made to the stewardship organization prior to the plan's termination or revocation.

(2) Make payments from the trust fund or escrow account as the department shall direct, in writing, to implement the most recently approved stewardship plan.

(c) If a new stewardship plan has not been approved by the department within one year after termination or revocation, the department may make modifications to the previously approved plan, as it deems necessary, and continue to direct payments from the trust fund or escrow account in accordance with paragraph (2) of subdivision (b) to implement the modified stewardship plan.

(d) A trustee or escrow agent in possession of stewardship funds shall, as directed by the department, transfer those funds to a successor stewardship organization with an approved stewardship plan.

42076. *(a) Except as provided in subdivision (c), an action specified in subdivision (b) that is taken by a stewardship organization or its members is not a violation of the Cartwright Act (Chapter 2 (commencing with Section 16700) of Part 2 of Division 7 of the Business and Professions Code), the Unfair Practices Act (Chapter 4* *(commencing with Section 17000) of Part 2 of Division 7 of the Business and Professions Code), or the Unfair Competition Law (Chapter 5 (commencing with Section 17200) of Part 2 of Division 7 of the Business and Professions Code).*

(b) Subdivision (a) shall apply to all of the following actions taken by a stewardship organization or its members:

(1) The creation, implementation, or management of a stewardship plan approved by the department pursuant to this article and the types or quantities of single-use packaging or priority single-use products managed pursuant to a stewardship plan.

(2) The cost and structure of an approved stewardship plan.

(3) The establishment, administration, collection, or disbursement of any charges associated with funding the implementation of this article.

(c) Subdivision (a) shall not apply to an agreement that does any of the following:

(1) Fixes a price of or for single-use packaging or priority single-use products, except for an agreement related to costs or charges associated with participation in a stewardship plan approved or conditionally approved by the department and otherwise in accordance with this article.

(2) Fixes the output of production of single-use packaging or priority single-use products.

(3) Restricts the geographic area in which, or customers to whom, single-use packaging or priority single-use products will be sold.

Article 5. California Circular Economy Regulatory Fee

42080. *(a) (1) The department shall establish, and a producer shall pay, a California circular economy regulatory fee. The amount of the fee shall be established and adjusted by the department based on the factors specified in paragraph (3). The department shall set this fee to collect no more than is necessary for the regulatory costs of this chapter for the following fiscal year, including a prudent reserve, as specified in subparagraph (B) of paragraph (3).*

(2) A producer shall remit the fee assessed pursuant to this subdivision to the department on a quarterly schedule for deposit into the California Circular Economy Fund, which is hereby created in the State Treasury. The revenue from the fee shall be tracked separately by the department and shall not be used for activities other than those described in this subdivision.

(3) Before establishing or adjusting the fee, the department shall review at a public hearing all of the following factors:

(A) A projection of the amount necessary to fund the reasonable regulatory costs incurred by the department incident to audits, inspections, administrative activities, adjudications, or other regulatory activities associated with single-use packaging and priority single-use products pursuant to this chapter, taking into account any revenue received from entities agreeing to corrective action plans.

(B) The sufficiency of revenues in the California Circular Economy Fund for the department to administer, enforce, and promote its regulatory activities regarding single-use packaging and priority single-use products, including the regulatory aspects of the programs established pursuant to this chapter, plus a prudent reserve.

(C) Whether additional revenues are necessary to preserve the department's ability to conduct regulatory activities in the following fiscal year.

(D) If the actual regulatory costs incurred by the department are lower than the projected costs, whether, at the end of the fiscal year, a sufficient net fund balance remains in the California Circular Economy Fund to reduce the fee.

(4) An adjustment to the fee shall become effective on January 1 of the year following its adoption.

(5) The department may adopt regulations to establish and adjust the fee. Regulations to adjust the fee shall be deemed to meet the description in subdivision (g) of Section 11340.9 of the Government Code and may be filed by the department pursuant to Section 11343.8 of the Government Code.

(b) (1) The amount of the fee imposed on a producer shall be proportionate to the cost of regulating that producer based on whether the producer is complying with this chapter individually or collectively as a member of a stewardship organization. If a producer is a member of a stewardship organization, the stewardship

organization shall be responsible for paying the fee on behalf of the producer. A stewardship organization may require a member to reimburse the stewardship organization for the amount of the regulatory fee paid on behalf of the member.

(2) The amount of the fee imposed on a producer shall be proportionate to the cost of regulating that producer based on whether the producer is a producer of single-use packaging or priority single-use products.

(3) If a fee paid by a producer pursuant to the California Beverage Container Recycling and Litter Reduction Act (Division 12.1 (commencing with Section 14500)) or any other programs relevant to this chapter results in reduced costs of regulating that producer under this chapter, the department shall account for that reduced cost of regulation when determining the amount of the California circular economy regulatory fee to impose on that producer.

(c) If the state loans money from a fund to the California Circular Economy Fund for managing single-use packaging or priority single-use products in the state, moneys in the California Circular Economy Fund may be used toward repaying a loan that was made before January 1, 2020, or any other loan of public funds made for the purposes set forth in this section.

SEC. 3. *Chapter 6 (commencing with Section 48710) is added to Part 7 of Division 30 of the Public Resources Code, to read:*

CHAPTER 6. Local Agency Regulation of Food Packaging Material

48710. *(a) For purposes of this chapter, the following definitions apply:*

(1) "Curbside program" means a recycling or composting program that picks up waste material from individual or multiple family residences, or both, with the intent to recycle or compost the waste material, operated by, or pursuant to a contract with, a local agency, or is acknowledged, in writing, by a local agency.

(2) "Grocery store" means a store primarily engaged in the retail sale of canned food, dry goods, fresh fruits and vegetables, and fresh meats, fish, and poultry, and any area that is not separately owned within the store where food is prepared and served, including a bakery, deli, and meat and seafood counter.

(3) "Local agency" means a city, county, city and county, or other local public agency.

(b) A local agency shall not require a grocery store to use a certain type of food packaging for any food sold in the grocery store unless the majority of residential households within the jurisdiction of the local agency have access to a curbside program that accepts the material from which that food packaging is made.

(c) A local agency shall not require a grocery store to use a food packaging container that does not meet an ASTM standard specification, as defined pursuant to subdivision (b) of Section 42356, or the compostability criteria developed pursuant to Section 42052.

(d) (1) Except as provided in paragraph (2), a local agency shall not enforce or implement an ordinance, resolution, regulation, or rule, or make any amendment to an ordinance, resolution, regulation, or rule, that violates or is in conflict with subdivision (b) or (c).

(2) A local agency that, as of September 15, 2019, has an ordinance, resolution, regulation, or rule that violates or is in conflict with subdivision (b) or (c) may continue to implement and enforce that ordinance, resolution, regulation, or rule.

(e) This chapter does not prohibit a local agency from requiring a grocery store to use a certain type of food packaging that is refillable or reusable.

(f) This chapter shall remain in effect only until January 1, 2030, and as of that date is repealed.

SEC. 4. *The Legislature finds and declares that Section 1 of this act, which adds Chapter 3 (commencing with Section 42040) to Part 3 of Division 30 of the Public Resources Code, imposes a limitation on the public's right of access to the meetings of public bodies or the writings of public officials and agencies within the meaning of Section 3 of Article I of the California Constitution. Pursuant to that constitutional provision, the Legislature makes the following findings to demonstrate the interest protected by this limitation and the need for protecting that interest:*

In order to protect the proprietary information of producers, retailers, and wholesalers of single-use packaging and priority single-use products, it is necessary that financial, production, and sales data reported by producers, retailers, and wholesalers of single-use packaging and priority single-use products be kept confidential.

SEC. 5. *No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs that may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, eliminates a crime or infraction, or changes the penalty for a crime or infraction, within the meaning of Section 17556 of the Government Code, or changes the definition of a crime within the meaning of Section 6 of Article XIII B of the California Constitution.*

AB-1080 Solid waste: packaging and products. (2019-2020)

SECTION 1. *Section 23671 of the Business and Professions Code is amended to read:*

23671. *(a)* No beer importer shall purchase any beer not manufactured within the state or cause any beer to be transported into the state for sale in the state, unless the out-of-state vendor making shipment of the beer into the state holds a certificate of compliance issued by the department. A certificate of compliance shall be granted when the out-of-state vendor makes a written agreement with the department to furnish to the board, on or before the 10th day of each month, a report on a form prescribed by the board, showing the quantity of beer shipped by the out-of-state vendor to each licensed beer importer in this state during the preceding month. The out-of-state vendor shall further agree that it and its agents and all agencies within this state controlled by it will comply with all laws of this state and all rules of the department with respect to the sale of alcoholic beverages, including, but not limited to, Chapter 12 (commencing with Section 25000) of Division 9, and Section 25509, to the same extent as licensees.

(b) If any out-of-state vendor, after obtaining the certificate, fails to submit the ~~report or~~ *report, fails* to comply with Section 14575 of the Public Resources Code, ~~the~~ *or fails to comply with the provisions of Chapter 3 (commencing with Section 42040) of Part 3 of Division 30 of the Public Resources Code, the* department may suspend or revoke the certificate of compliance in the manner provided for the suspension or revocation of licenses, and after a hearing which shall be held in the City of Sacramento or in any other county seat in this state which the department determines to be convenient to the holder of the certificate. No fee shall be charged for the certificate of compliance which shall remain in effect until revoked by the department.

SEC. 2. *Chapter 3 (commencing with Section 42040) is added to Part 3 of Division 30 of the Public Resources Code, to read:*

CHAPTER 3. California Circular Economy and Pollution Reduction Act
Article 1. General Provisions

42040. *This chapter shall be known, and may be cited, as the California Circular Economy and Pollution Reduction Act.*

42041. *(a) The Legislature finds and declares all of the following:*

(1) Annual global production of plastic has reached 335 million tons and continues to rise. The United States alone discards 30 million tons each year. Global plastic production is projected to more than triple by 2050, accounting for 20 percent of all fossil fuel consumption.

(2) Without action, projections estimate that by 2050 the mass of plastic pollution in the ocean will exceed the mass of fish. A study by the University of Exeter and Plymouth Marine Laboratory in the United Kingdom found plastics in the gut of every single sea turtle examined and in 90 percent of seabirds. Additionally, plastic negatively affects marine ecosystems and wildlife, as demonstrated by countless seabirds, turtles, and marine mammals, including, but not limited to, whales and dolphins, dying from plastic ingestion or entanglement.

(3) Based on data from the United States Environmental Protection Agency, Institute of Scrap Recycling Industries trade statistics, and industry news source Resource Recycling, the national recycling rate for plastic is projected to sink from 9.1 percent in 2015 to 4.4 percent in 2018, and could drop to 2.9 percent in 2019. Even in California, less than 15 percent of single-use plastic is recycled.

(4) Before 2017, the United States was sending 4,000 shipping containers a day full of American waste to China every year, including two-thirds of California's recyclable materials. However, China has implemented the Green Fence, National Sword, and Blue Sky policies, severely restricting the amount of contaminated and poorly sorted plastics it would accept. This shift in China's policy has resulted in the loss of markets for low-value plastic packaging that was previously considered recyclable. That material is now being landfilled or burned.

(5) Additionally, the foreign market for recycled paper has collapsed in California. Foreign exports of mixed paper fell from over 400,000 tons in the first quarter of 2017 to just 136,000 tons in the first quarter of 2018. The price of mixed paper fell from ninety-five dollars ($95) per ton to just ten dollars ($10) a ton in the same timeframe.

(6) The loss of markets for recyclable material has added huge costs to local governments for the disposal and diversion of material. For many cities, counties, and waste haulers in California, recycling has turned from a profitable business into an activity that actually costs local governments money. These costs are being absorbed by city general funds or by rate increases on residents for waste collection.

(7) The environmental and public health impacts of plastic pollution are devastating and the environmental externalities and public costs of cleaning up and mitigating plastic pollution are already staggering and continue to grow.

(8) Local governments in California annually spend in excess of four hundred twenty million dollars ($420,000,000) in ongoing efforts to clean up and prevent plastic and other litter from entering our rivers and streams and polluting our beaches and oceans.

(9) Evidence now shows that even our own food and drinking water sources are contaminated with plastic. Microplastics have been found in tap water, bottled water, table salt, and fish and shellfish from local California fish markets. A growing body of research is finding plastic and associated toxins throughout the food web, including in our blood, feces, and tissues. Exposure to these toxins has been linked to cancers, birth defects, impaired immunity, endocrine disruption, and other ailments.

(10) It is the policy goal of the state that not less than 75 percent of solid waste generated be source reduced, recycled, or composted by the year 2020. However, as of 2017, the state was only on track to reach 44 percent, falling far short of this important goal. Additionally, the state has done little to require businesses to reduce the amount of packaging and single-use product waste they generate in California.

(11) As the fifth largest economy in the world, California has a responsibility to lead on solutions to the growing plastic pollution crisis, and to lead in the reduction of unnecessary waste generally.

(12) Further, businesses selling products into California have a responsibility to ensure that their packaging and products are minimizing waste, including ensuring materials used are reusable, recyclable, or compostable. This responsibility includes paying for the cost of the negative externality of recovery for materials they sell in California.

(b) (1) Consistent with the policy goal established in Section 41780.01, it is the intent of the Legislature that, by 2030, producers of single-use products that are not priority single-use products achieve and maintain a statewide 75-percent reduction of the waste generated from single-use products offered for sale, sold, distributed, or imported in or into the state that are not priority single-use products through source reduction, recycling, or composting.

(2) In accordance with paragraph (1), it is the intent of the Legislature that producers of single-use products that are not priority single-use products do all of the following for single-use products that are not priority single-use products:

(A) Source reduce those products, and transition those products to reusable products, to the maximum extent feasible.

(B) Ensure those products are recyclable or compostable, as determined by the department pursuant to Section 42052.

(C) For single-use plastic products that are not priority single-use products and that are offered for sale, sold, distributed, or imported in or into California, reduce waste generation by 75 percent through combined source reduction and recycling.

(c) It is the intent of the Legislature that any deposit-based mechanism identified pursuant to clause (ii) of subparagraph (B) of paragraph (2) of subdivision (b) of Section 42050 or implemented as a corrective action pursuant to paragraph (2) of subdivision (a) of Section 42061 ensures that consumers can conveniently receive a refund for returning single-use packaging or priority single-use products.

***42042.** (a) For purposes of this chapter, all of the following shall apply:*

(1) "California circular economy regulatory fee" means the fee imposed by the department pursuant to Section 42080.

(2) "Packaging" means the material used for the containment, protection, handling, delivery, or presentation of goods by the producer for the user or consumer, ranging from raw materials to processed goods. Packaging includes, but is not limited to, all of the following:

(A) Sales packaging or primary packaging intended to constitute a sales unit to the consumer at point of purchase and most closely contains the product, food, or beverage.

(B) Grouped packaging or secondary packaging intended to brand or display the product.

(C) Transport packaging or tertiary packaging intended to protect the product during transport.

(3) "Packaging category" means a packaging material category on the list published by the department pursuant to subdivision (c) of Section 42054.

(4) "Priority single-use products" means single-use food service ware, including plates, bowls, cups, utensils, stirrers, and straws.

(5) "Product category" means a priority single-use product material category on the list published by the department pursuant to subdivision (c) of Section 42054.

(6) (A) "Producer" means the person who manufactures the single-use packaging or priority single-use product under that person's own name or brand and who sells or offers for sale the single-use packaging or priority single-use product in the state.

(B) If there is no person who is the producer of the single-use packaging or priority single-use products for purposes of subparagraph (A), the producer is the person who imports the single-use packaging or priority single-use product as the owner or licensee of a trademark or brand under which the single-use packaging or priority single-use product is sold or distributed in the state.

(C) If there is no person who is the producer for purposes of subparagraphs (A) and (B), the producer is the person or company that offers for sale, sells, or distributes the single-use packaging or priority single-use product in the state.

(D) Notwithstanding subparagraphs (A) to (C), inclusive, for beer and malt beverages manufactured outside of the state "producer" means the person named on the certificate of compliance issued pursuant to Section 23671 of the Business and Professions Code.

(7) "Retailer or wholesaler" means the person who sells the single-use packaging, product packaged in single-use packaging, or priority single-use product in the state or offers to consumers the single-use packaging, product packaged in single-use packaging, or priority single-use product in the state through any means, including, but not limited to, any of the following:

(A) Remote offering, including sales outlets or catalogs.

(B) Electronically through the internet.

(C) Telephone.

(D) Mail.

(8) (A) "Single-use packaging" means the packaging of a product when the packaging is routinely recycled, disposed of, or discarded after its contents have been used or unpackaged, and typically not refilled by the producer.

(B) Single-use packaging does not include any of the following:

(i) Reusable packaging, as determined by the department pursuant to Section 42052.

(ii) Packaging containing toxic or hazardous products regulated by the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 136 et seq.).

(iii) Plastic packaging containers that are manufactured for use in the shipment of hazardous materials and are prohibited from being manufactured with used material by federal packaging material specifications set forth in Sections 178.509 and 178.522 of Title 49 of the Code of Federal Regulations.

(iv) Until January 1, 2026, beverage containers subject to the California Beverage Container Recycling and Litter Reduction Act (Division 12.1 (commencing with Section 14500)).

(9) "Source reduction" includes, but is not limited to, transitioning single-use packaging or a priority single-use product to refillable or reusable packaging or a reusable product. Source reduction does not include replacing a recyclable or compostable material with a nonrecyclable or noncompostable material or a material that is less likely to be recycled or composted, and does not include a shift from a nonplastic material that currently is recyclable or compostable to plastic material.

(10) "Unexpended funds" means money in a stewardship organization's accounts that the stewardship organization is not already obligated to pay pursuant to a contract, claim, or similar mechanism. "Unexpended funds" excludes regulatory fees.

(b) For purposes of this chapter, all of the following shall not be considered single-use packaging or priority single-use products:

(1) Medical products, as well as products defined as medical devices and prescription drugs as specified in the federal Food, Drug, and Cosmetic Act (21 U.S.C. Secs. 321(h) and (g), and Sec. 353(b)(1)).

(2) Drugs that are used for animal medicines, including, but not limited to, parasiticide products for animals.

(3) Infant formula, as defined in Section 321(z) of Title 21 of the United States Code.

(4) Medical food as defined pursuant to Section 360ee(b)(3) of Title 21 of the United States Code.

(5) Fortified oral nutritional supplements used for persons who require supplemental or sole source nutrition to meet nutritional needs due to special dietary needs directly related to cancer, chronic kidney disease, diabetes, or other medical conditions as determined by the department.

(6) Packaging used for a product listed in paragraphs (1) to (5), inclusive.

Article 2. Single-use Packaging and Priority Single-use Products

***42050.** (a) Before January 1, 2024, the department shall, in consultation with relevant state agencies with jurisdiction relevant to this chapter and local jurisdictions and regional agencies charged with meeting waste diversion goals, adopt regulations that do all of the following:*

(1) (A) Require producers of single-use packaging to source reduce single-use packaging to the maximum extent feasible.

(B) Require producers of single-use packaging to ensure that all single-use packaging manufactured on or after January 1, 2030, and that is offered for sale, sold, distributed, or imported in or into California is recyclable or compostable as determined by the department pursuant to Section 42052.

(2) (A) Require producers of priority single-use products to source reduce priority single-use products to the maximum extent feasible.

(B) Require producers of priority single-use products to ensure that priority single-use products manufactured on or after January 1, 2030, and that are offered for sale, sold, distributed, or imported in or into California are recyclable or compostable as determined by the department pursuant to Section 42052.

(3) Achieve and maintain, by January 1, 2030, through the regulations adopted by the department and implemented by producers pursuant to this chapter, a statewide 75-percent reduction of the waste generated from single-use packaging and priority single-use products offered for sale, sold, distributed, or imported in or into the state through source reduction, recycling, or composting.

(4) Require producers to comply with the requirements of this chapter and its implementing regulations.

(b) (1) By January 1, 2023, and before adopting the regulations, in order to increase the opportunity for public participation and to receive comments, the department shall finalize an implementation plan for meeting the requirements of this chapter.

(2) As part of the implementation plan, the department shall do all of the following:

(A) Conduct extensive outreach to stakeholders and to state and local agencies with jurisdiction relevant to this chapter, including, but not limited to, the state's waste diversion, climate, water quality, public health, and air quality goals, and the state's toxic substances regulation. This outreach shall include, but is not limited to, convening a series of public workshops throughout the state to give interested parties an opportunity to comment and a series of stakeholder meetings designed to facilitate dialogue between stakeholders representing different interest groups such as local governments, the solid waste and recycling industries, product and packaging

manufacturers, retailers and wholesalers, trade associations, and environmental organizations. These meetings shall be held throughout the state to increase the opportunity for participation and shall inform the development of regulations pursuant to this section.

(B) Evaluate all of the following:

(i) Incentives and policies to maximize and encourage in-state manufacturing using recycled material generated in California and the development of reusable packaging and products.

(ii) Economic mechanisms to reduce the distribution of single-use packaging and priority single-use products or to transition single-use packaging and priority single-use products to reusable alternatives and increase the recyclability or compostability of single-use packaging and priority single-use products. These economic mechanisms may include, but are not limited to, allowing producers to establish and operate a collection and deposit program, assess a generation-based fee, an advanced recycling fee, pay as you throw fees, or extended producer responsibility for single-use packaging and priority single-use products.

(iii) Avoiding the litter, export, or improper disposal of single-use packaging, priority single-use products, and other materials likely to harm the environment or public health in California or elsewhere in the world.

(iv) Labeling requirements regarding the recyclability, compostability, or reusability of packaging and priority single-use products. Labeling requirements may include criteria for packaging to be labeled "recyclable," "compostable," "reusable," or "refillable" based on factors including, but not limited to, whether the packaging or product can be readily recycled, composted, or reused and whether the packaging or product is likely to contaminate other recyclable or compostable material or complicate processing. In developing labeling requirements, the department shall consider national and international labeling standards and systems.

(v) Possible options for producers to implement the requirements of this chapter and reduce packaging and product waste, including, but not limited to, through implementation of effective and convenient take-back opportunities, deposit systems, reusable and refillable delivery systems, designing for recyclability or compostability, advanced disposal fees, incentive programs, or similar mechanisms. The department may allow producers to implement extended producer responsibility programs, where appropriate, consistent with the requirements of Article 4 (commencing with Section 42070).

(vi) Actions identified through the California Ocean Litter Prevention Strategy and the Statewide Microplastics Strategy.

(vii) Establishing criteria for the source reduction requirements specified in subdivision (a) and to inform the checklist specified in paragraph (3) of subdivision (h). Consideration shall include reducing weight, volume, or quantity of single-use packaging and priority single-use product material in a way that does not decrease the ability of the material to be recycled or reused.

(viii) Establishing minimum postconsumer recycled content requirements for a packaging or product category, where appropriate, in order to create or enhance markets for recycled material.

(ix) How to address technological innovations and new packaging materials or categories.

(C) Consider and provide recommendations on whether to transition or sunset existing recycling programs.

(D) Identify all of the following:

(i) Opportunities to improve and expand waste collection and processing capabilities and infrastructure, including the use of innovative new recycling and reuse technologies and secondary material recovery facilities.

(ii) Opportunities to harmonize local waste, recycling, and composting programs among local jurisdictions and barriers to cooperation and standardization of programs.

(iii) Opportunities for encouraging the use of reusable or refillable packaging.

(iv) Opportunities for public education efforts to increase recycling and composting of single-use packaging and priority single-use products and reducing litter from these items.

(v) Potential end-use markets for collected materials and policies required to stimulate domestic markets.

(vi) Opportunities for incentivizing and increasing consumer recycling.

(vii) Discussion for identifying and conducting outreach to producers.

(c) (1) The department may identify single-use packaging or priority single-use products that, while determined to be single use for purposes of this chapter, present unique challenges in complying with this chapter.

(2) For any packaging or products identified as presenting unique challenges, the department may at any point develop a plan to phase the packaging or products into the regulations.

(d) The department shall ensure that any regulations adopted pursuant to this chapter account for guidelines and regulations issued by the United States Food and Drug Administration.

(e) If the department determines at any point a type of single-use packaging or priority single-use product cannot comply with this chapter due to health and safety reasons, or because it is unsafe to recycle, the department may exempt that packaging or product from this chapter.

(f) The regulations shall establish a baseline for the 75-percent waste reduction requirement in subdivision (a) for each packaging and product category based on waste characterization studies undertaken by the department, and any other information received by the department.

(g) (1) Producers shall do both of the following:

(A) Register with the department.

(B) Report any data to the department that the department deems necessary to determine compliance with this chapter in a form, manner, and frequency determined by the department.

(2) Any confidential or proprietary market sensitive data received by the department pursuant to this chapter shall be held confidentially by the department as required by Section 40062 and any implementing regulations.

(3) The department shall create an online registration form to facilitate submitting reports pursuant to this subdivision.

(4) Producers shall submit the information required by the department pursuant to paragraph (1) using the format established by the department pursuant to paragraph (3).

(5) The department's regulations shall establish appropriate timelines to begin reporting following the adoption of regulations. The department shall consider the amount of information being reported in developing the timelines.

(h) (1) The department's regulations shall include direct source reductions of single-use packaging and priority single-use products to the maximum extent feasible, in accordance with this section.

(2) The department may consider single-use packaging and priority single-use product reductions achieved by a producer before the effective date of the regulations if the producer can demonstrate to the satisfaction of the department that the producer reduced the single-use packaging or priority single-use product in a manner consistent with this chapter.

(3) (A) The department shall develop a checklist of source reduction measures, and a producer that complies with all applicable measures on the checklist shall be in compliance with the requirement to source reduce to the maximum extent feasible pursuant to subdivision (a). The department shall also offer guidance on how to use the checklist as a means of complying with subdivision (a). The checklist measures may include, but are not limited to, ensuring the single-use packaging or priority single-use product remains recyclable or compostable, right-sizing products, eliminating excess packaging, compliance with internal or third-party certified packaging design guidelines, concentrating a product to reduce packaging, and transitioning to reusable alternatives where those alternatives are readily available.

(B) To determine which source reduction measures to include in the checklist, the department shall consider which single-use packaging and priority single-use products are prone to become litter, have readily available alternatives, make up a significant portion of the waste stream, or have established, or have the potential for, recycling or composting infrastructure.

(C) The checklist shall incorporate considerations that assist the department in evaluating whether it is feasible for a producer to implement one or more of the checklist source reduction measures, including product protection and integrity, consumer safety, shelf life, compatibility with distribution systems, and other relevant factors as the department deems appropriate.

(4) When establishing the source reduction measures, the department shall avoid incentivizing substitutions that may have a more substantial negative impact on the environment.

(5) In developing the regulations, the department shall count a producer's source reductions achieved to comply with Chapter 5.5 (commencing with Section 42300) toward compliance with this chapter.

(6) If the department believes a producer has not met its obligation to source reduce to the maximum extent feasible, or if the department believes additional source reduction is feasible when the producer believes it is not, then the producer shall be given an opportunity to explain any relevant factors that would limit its ability to meet its obligation or implement additional source reduction measures.

(i) If the department determines that early actions to source reduce certain single-use packaging and priority single-use products can further the purposes of this chapter, the department may adopt regulations to achieve those reductions. If the department adopts regulations pursuant to this subdivision, the department shall report that action to the Legislature in the next report submitted pursuant to Section 42060.

(j) In developing the regulations, the department shall consider relevant information on reduction programs and approaches in other states, localities, and nations, including, but not limited to, the European Union, India, Costa Rica, and Canada, and international standards, including, but not limited to, ISO 18602.

(k) The department may determine which actions producers may undertake to achieve the requirements of subdivision (a) based on packaging or product category.

(l) In adopting regulations pursuant to this section, the department shall consider and avoid disproportionate impacts to low-income or disadvantaged communities.

(m) The department shall not impose a recycled content requirement or any other requirement in direct conflict with a federal law or regulation, including, but not limited to, laws or regulations covering tamper-evident packaging pursuant to Section 211.132 of Title 21 of the Code of Federal Regulations, laws or regulations covering child-resistant packaging pursuant to Part 1700 of Subchapter E of Chapter II of Title 16 of the Code of Federal Regulations, or requirements for microbial contamination, structural integrity, or safety of packaging under the federal Food, Drug, and Cosmetic Act (21 U.S.C. Sec. 301 et seq.), 21 U.S.C. Sec. 2101 et seq., the federal FDA Food Safety Modernization Act (21 U.S.C. Sec. 2201 et seq.), or the regulations, rules, or guidance issued pursuant to those laws.

(n) The department shall develop criteria for exemptions from the requirements of this chapter for small producers, retailers, and wholesalers.

(o) The department shall establish criteria for allowing producers to comply with the requirements of this chapter through contractual arrangements with third parties that do not otherwise meet the definition of producer in subparagraph (A) of paragraph (6) of subdivision (a) of Section 42042. The criteria shall not limit the department's ability to enforce or otherwise implement this chapter.

42051. *(a) The department may adopt emergency regulations to implement and enforce all of the following:*

(1) Subdivision (g) of Section 42050.

(2) Subdivision (i) of Section 42050.

(3) Subdivisions (c) and (d) of Section 42054.

(4) Section 42055.

(5) Section 42080.

(b) Emergency regulations adopted pursuant to this section shall be adopted in accordance with Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code, and for the purposes of that chapter, including Section 11349.6 of the Government Code, the adoption of these regulations is an emergency and shall be considered by the Office of Administrative Law as necessary for the immediate preservation of the public peace, health, safety, and general welfare. Notwithstanding Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code, any emergency regulations adopted by the department pursuant to this section shall be filed with, but not be repealed by, the Office of Administrative Law and shall remain in effect for a period of two years or until revised by the department, whichever occurs sooner.

42052. *(a) In adopting regulations pursuant to Section 42050, the department shall develop criteria to determine whether the packaging or priority single-use products are reusable, recyclable, or compostable.*

(b) (1) For purposes of determining if single-use packaging or priority single-use products are recyclable, the

director shall consider, at a minimum, all of the following criteria:

(A) Whether the single-use packaging or priority single-use product is eligible to be labeled as "recyclable" in accordance with the uniform standards contained in Article 7 (commencing with Section 17580) of Chapter 1 of Part 3 of Division 7 of the Business and Professions Code.

(B) Whether the single-use packaging or priority single-use product is regularly collected, separated, and cleansed for recycling by recycling service providers.

(C) Whether the single-use packaging or priority single-use product is regularly sorted and aggregated into defined streams for recycling processes.

(D) Whether the single-use packaging or priority single-use product is regularly processed and reclaimed or recycled with commercial recycling processes.

(E) Whether the single-use packaging or priority single-use product material regularly becomes feedstock that is used in the production of new products.

(F) Whether the single-use packaging or priority single-use product material is recycled in sufficient quantity, and is of sufficient quality, to maintain a market value.

(2) For purposes of determining if single-use packaging or priority single-use products are recyclable, the director shall consider the regulations adopted pursuant to Article 10.4 (commencing with Section 25214.11) of Chapter 6.5 of Division 20 of the Health and Safety Code.

(3) For purposes of determining if single-use packaging or priority single-use products are recyclable, de minimis amounts of nonrecyclable material of more than 3 percent of the total weight or volume of the single-use packaging or priority single-use product material is acceptable when the nonrecyclable material is required for the proper delivery, safety, sterility, stability, or use of the product or the product contained within the packaging. If the nonrecyclable material negatively affects the recyclability of the product or packaging, the material shall not be considered de minimis.

(c) For purposes of determining if single-use packaging or priority single-use products are compostable, the director shall consider, at a minimum, all of the following criteria:

(1) Whether the single-use packaging or priority single-use product will, in a safe and timely manner, break down or otherwise become part of usable compost that can be composted in a public or private compost facility designed for and capable of processing postconsumer food waste and food-soiled paper.

(2) Whether the single-use packaging or priority single-use product made from plastic is certified to meet the ASTM standard specification identified in either subparagraph (A) or (C) of paragraph (1) of subdivision (b) of Section 42356 and adopted in accordance with Section 42356.1, if applicable.

(3) Whether the single-use packaging or priority single-use product is regularly collected and accepted for processing at public and private compost facilities.

(4) Whether the single-use packaging or priority single-use product is eligible to be labeled as "compostable" in accordance with the uniform standards contained in Article 7 (commencing with Section 17580) of Chapter 1 of Part 3 of Division 7 of the Business and Professions Code.

(d) For purposes of determining if packaging or a priority single-use product is reusable, the department shall consider, at a minimum, both of the following criteria:

(1) Whether the packaging or priority single-use product is conventionally disposed of after a single use.

(2) Whether the packaging or priority single-use product is sufficiently durable, washable, and intended for multiple refills of the original product to allow for multiple uses.

(e) (1) In implementing this section, the department may consult with local governments and representatives of the solid waste industry, the recycling industry, the reuse industry, the compost industry, and single-use product and packaging manufacturers to determine if a type of packaging or priority single-use product is recyclable, reusable, or compostable.

(2) Local governments, solid waste facilities, recycling facilities, and composting facilities may provide information requested by the department pursuant to paragraph (1) to the department.

42053. *(a) In implementing this chapter, the department shall establish a Circular Economy and Waste Pollution Reduction Panel for the purpose of identifying barriers and solutions to creating a circular economy consistent with this chapter. The panel shall be composed of one or more members from each of the following disciplines, with equal representation from each discipline:*

(1) Local government.

(2) Waste management.

(3) Environmental health or sustainability.

(4) Product or packaging manufacturing.

(5) Product or packaging design.

(6) Recyclers.

(b) The department shall appoint all members to the panel on or before January 1, 2021. The department shall appoint the members for staggered three-year terms, and may reappoint a member for additional terms, without limitation.

(c) The panel shall meet as often as the department deems necessary, with consideration of available resources, but not less than twice each year. The department shall provide for staff and administrative support to the panel.

(d) The panel meetings shall be open to the public and are subject to the Bagley-Keene Open Meeting Act (Article 9 (commencing with Section 11120) of Chapter 1 of Part 1 of Division 3 of Title 2 of the Government Code).

(e) The panel shall provide the department with initial recommendations regarding key barriers and possible solutions to advance the objectives of increasing recovery of packaging and product materials and decreasing the leakage of plastic into the environment no later than one year after the panel's initial meeting. The department shall consider these recommendations as it evaluates what specific actions may be appropriate to advance the objectives of this chapter.

(f) The panel may take any of the following actions through written recommendations as the panel deems appropriate:

(1) Advise the department on technical matters in support of the goals of this chapter to create a circular economy and reduce product and packaging pollution.

(2) Advise the department in the adoption of the implementation plan and regulations required by this chapter.

(3) Advise the department on any other pertinent matter in implementing this chapter, as determined by the panel or department.

(g) The panel shall submit written recommendations to the department only if a majority or more of the panel's members endorse the recommendation. One or more panel members that do not endorse the recommendation may submit a separate written recommendation to the department reflecting the minority opinion or opinions.

42054. *(a) Single-use packaging and priority single-use products offered for sale, sold, distributed, or imported in or into California by a producer shall meet the following recycling rates:*

(1) On and after January 1, 2026, not less than 30 percent for single-use packaging and priority single-use products manufactured on or after January 1, 2026.

(2) On and after January 1, 2028, not less than 40 percent for single-use packaging and priority single-use products manufactured on or after January 1, 2028.

(3) On and after January 1, 2030, not less than 75 percent for single-use packaging and priority single-use products manufactured on or after January 1, 2030.

(b) (1) Notwithstanding subdivision (a), the department may, subject to paragraph (3), impose a higher or lower recycling rate for single-use packaging or priority single-use products as needed to achieve the requirements established in Section 42050.

(2) Commencing in 2024, and every two years thereafter, the department shall review, in consultation with the panel created pursuant to Section 42053, relevant data to assess whether the recycling rate required in subdivision (a) should be adjusted. The department shall make its determination and rationale available for public

review.

(3) If the department determines pursuant to a review under paragraph (2) that current unforeseen and anomalous market conditions, including, but not limited to, recycling infrastructure conditions, warrant an adjustment to the recycling rates required in subdivision (a), the department may impose a higher or lower recycling rate subject to the following conditions:

(A) The recycling rate shall not be adjusted by more than 10 percent of what is required in subdivision (a).

(B) The adjusted recycling rate shall be in effect for no more than two years.

(c) (1) Before adopting the implementation plan or regulations, the department shall establish and post on its internet website a list of packaging and product categories of single-use packaging and priority single-use products.

(2) The department may consider material types and form referenced in waste characterization studies for determining the packaging and product categories.

(d) (1) The department shall calculate and publish on its internet website the recycling rates for each packaging and product category no later than January 1, 2025. These recycling rates shall be deemed to meet the description in subdivision (g) of Section 11340.9 of the Government Code and may be filed by the department pursuant to Section 11343.8 of the Government Code.

(2) In determining a recycling rate, the department may consider data gathered pursuant to any of the following:

(A) Chapter 746 of the Statutes of 2015.

(B) Chapter 6 (commencing with Section 42370).

(C) Chapter 395 of the Statutes of 2016.

(D) Chapter 5.5 (commencing with Section 42300).

(E) Division 12.1 (commencing with Section 14500).

(F) Data voluntarily provided by local jurisdictions.

(G) Data and information received from producers.

(H) Any other relevant data and information received by the department.

(3) The department shall determine and post on its internet website whether each packaging and product category recycling rate complies with the recycling rates required pursuant to this section.

(4) For purposes of determining the recycling rate, the department shall include single-use packaging and priority single-use products that are recycled or composted.

(5) A producer may demonstrate compliance with subdivision (a) or (b) by submitting to the department evidence that the particular type of single-use packaging or priority single-use product meets the applicable recycling rate threshold established in subdivision (a) or (b) by reference to a recycling rate on the department's list or through another mechanism approved by the department.

(6) The department shall update the list at least every two years and shall regularly, but no less than once every two years, evaluate the list of recycling rates to determine whether the recycling rates are still accurate. After evaluation, the department may amend the list to remove, add, or change recycling rates. The department shall post any updates to the list on its internet website.

(7) A producer that seeks to have a recycling rate included or changed on the list, or a packaging or product category added to the list, may be required by the department to submit data for purposes of the department's determination of the recycling rate to include on the list.

(8) Development of, publication of, and updates made to the list pursuant to this subdivision are exempt from Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code.

42054.1. *The department shall post on its internet website a list of compliant producers that are in compliance with this chapter and a list of noncompliant producers that are not in compliance with this chapter. The department shall update the list at least once every six months.*

42055. *(a) A retailer and wholesaler shall register with the department and do both of the following:*
(1) Report to the department the producers that provide the retailer or wholesaler with single-use packaging, products packaged in single-use packaging, or priority single-use products.

(2) Not offer for sale or sell single-use packaging, a product packaged in single-use packaging, or a priority single-use product if the producer of the single-use packaging or priority single-use product is listed as noncompliant on the department's internet website pursuant to Section 42054.1.

(b) The department may require electronic registration and reporting by retailers and wholesalers.

42056. *(a) In complying with this chapter, producers, retailers, and wholesalers shall do all of the following:*

(1) Upon request, provide the department with reasonable and timely access to its facilities and operations, as necessary to determine compliance with this chapter.

(2) Upon request, provide the department with relevant records necessary to determine compliance with this chapter.

(b) Provide required reports and data that are accurate and attested to under penalty of perjury as required by the department.

Article 3. Implementation and Enforcement
42060. *The department shall report to the Legislature in compliance with Section 9795 of the Government Code every three years its progress in implementing this chapter. The implementation plan required by Section 42050 shall constitute a report for the purposes of this section.*

42061. *(a) (1) The department may issue a notice of violation to and impose an administrative civil penalty not to exceed fifty thousand dollars ($50,000) per day per violation on any entity not in compliance with this chapter or any of the regulations the department adopts to implement this chapter.*

(2) Before determining whether or not to assess a penalty, the department may require a producer to develop and submit a corrective action plan to the department detailing how the producer will come into compliance with this chapter. Corrective action plans may include, but are not limited to, actions such as shifting production away from packaging and product categories that do not meet the recycling rates required pursuant to Section 42054, reaching a minimum content standard set by the department, or establishing a take-back system or deposit fee system for single-use packaging or priority single-use products that would increase the recycling rate of the material. The department shall not assess a penalty and the producer shall remain listed as compliant pursuant to Section 42054.1 if the producer complies with the corrective action plan. A producer may request approval from the department to comply with a corrective action plan or elements of a corrective action plan through a joint venture or joint actions with other producers.

(3) The department, in determining the penalty amount and whether or not to assess a penalty, shall consider all of the following:

(A) The nature, circumstances, extent, and gravity of the violation or a condition giving rise to the violation and the various remedies and penalties that are appropriate in the given circumstances, with primary emphasis on protecting the public health and safety and the environment.

(B) Whether the violation or conditions giving rise to the violation have been corrected in a timely fashion or whether reasonable progress is being made to correct the violation or conditions giving rise to the violation.

(C) Whether the violation or conditions giving rise to the violation demonstrate a chronic pattern of noncompliance with this chapter or the regulations adopted pursuant to this chapter.

(D) Whether the violation or conditions giving rise to the violation were intentional.

(E) Whether the violation or conditions giving rise to the violation were voluntarily and promptly reported to the department before the commencement of an investigation or audit by the department.

(F) Whether the violation or conditions giving rise to the violation were due to circumstances beyond the reasonable control of the producer or were otherwise unavoidable under the circumstances, including, but not limited to, unforeseen changes in market conditions.

(G) The size and economic condition of the producer.

(4) (A) The department may extend a previously established timeframe for a producer to comply with a corrective

action plan for up to 24 months if the department sets forth steps for the producer to achieve compliance with the corrective action plan and if the producer has demonstrated that it has made a substantial effort to comply and that there are extenuating circumstances that have prevented it from complying.

(B) For purposes of this paragraph, "substantial effort" means that a producer has taken all practicable actions to comply with a corrective action plan. Substantial effort does not include circumstances in which the decisionmaking body of a producer has not taken the necessary steps to comply with a corrective action plan, including, but not limited to, a failure to provide staff resources or a failure to provide sufficient funding to ensure compliance with a correction action plan.

(b) A producer may offer for sale, sell, distribute, or import single-use packaging or priority single-use products in a packaging or product category that does not meet the recycling rates established pursuant to subdivision (a) or (b) of Section 42054 if the producer demonstrates to the department that the producer has implemented actions to achieve the recycling rates established pursuant to subdivision (a) or (b) of Section 42054 for an amount equal to the producer's market share of that packaging or product category in California.

(c) (1) The department may audit producers, retailers, and wholesalers including, but not limited to, reports submitted by a producer and demonstrations made by a producer pursuant to Section 42054.

(2) The department shall review an audit for compliance with this chapter and consistency with information reported pursuant to this chapter.

(3) The department shall notify a producer, retailer, or wholesaler, of any conduct or practice that does not comply with this chapter or of any inconsistencies identified in the department's audit.

(4) A producer, retailer, or wholesaler may obtain copies of the department's audit of the producer upon request.

(5) The department shall not disclose any confidential or proprietary information that is included in the department's audit to the extent that information is protected from disclosure by existing law.

(d) Subdivision (a) does not apply to the requirements of paragraph (1) of subdivision (a) of Section 42054. The department may notify the producer of the failure to comply with the requirements of paragraph (1) of subdivision (a) of Section 42054.

Article 4. Single-use Packaging and Priority Single-use Product Stewardship

42070. *(a) The department may adopt regulations allowing producers to meet the requirements of this chapter collectively by forming a stewardship organization that adopts a stewardship plan in accordance with this article. If the department adopts those regulations, the regulations shall include all of the provisions of this article.*

(b) A producer that is a member of a stewardship organization, which is formed in accordance with this article and is in compliance with this chapter, shall not individually be subject to the requirements of this chapter for the single-use packaging and priority single-use products covered by the stewardship plan, except as specified in a stewardship plan adopted by a stewardship organization in accordance with this article.

(c) In accordance with Section 42080, a stewardship organization formed in accordance with this article shall be responsible for paying the California circular economy regulatory fee on behalf of its members and may require a member to reimburse the stewardship organization for the amount of the regulatory fee paid on behalf of the member.

42071. *(a) Producers may form a stewardship organization exempt from taxation under Section 501(c)(3) of the federal Internal Revenue Code of 1986.*

(b) A stewardship organization formed pursuant to subdivision (a) shall develop and submit to the department a stewardship plan for the source reduction, collection, and recycling of the single-use packaging or priority single-use products that the producers covered under the plan sell, offer for sale, distribute, or import in or into the state in an economically efficient and practical manner. The stewardship plan shall be consistent with the regulations adopted in accordance with Section 42050.

(c) Within 90 days after approval or conditional approval by the department of the plan, the stewardship organization shall implement the approved plan.

(d) The approved plan shall be a public record, except that financial, production, or sales data reported to the department by the stewardship organization is not a public record for purposes of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1 of the Government Code) and shall not be open to public inspection. The department may release financial, production, or sales data in summary form so

the information cannot be attributable to a specific producer, retailer, wholesaler, or to any other entity.

42072. *(a) The stewardship organization shall keep minutes, books, and records that clearly reflect the activities and transactions of the stewardship organization.*

(b) The accounting books of the stewardship organization shall be audited at the stewardship organization's expense by an independent certified public accountant retained by the stewardship organization at least once each calendar year.

(c) The stewardship organization shall arrange for the audit to be delivered to the department with the annual report required pursuant to Section 42073. The department shall review the audit for compliance with this article and consistency with the plan created pursuant to this article. The department shall notify the stewardship organization of any compliance issues or inconsistencies.

(d) The department may conduct its own audit if it determines that an audit is necessary to enforce the requirements of this article and that the audit conducted pursuant to subdivision (b) is not adequate for this purpose. The stewardship organization may obtain copies of the audit upon request.

(e) The department shall not disclose any confidential or proprietary information in an audit.

42073. *The stewardship organization shall annually submit to the department and make publicly available on its internet website an annual report that describes how the organization has complied with the requirements of this chapter and its implementing regulations.*

42074. *(a) The department shall review the annual report for compliance with this article and shall approve, disapprove, or conditionally approve the report within 120 days of receipt of the annual report.*

(b) If the department disapproves the annual report, the department shall explain, in writing, how the annual report does not comply with this article, and the stewardship organization shall resubmit the report with any additional information, modifications, or corrections to the department within 30 days. If the department finds that the annual report resubmitted by the stewardship organization does not comply with the requirements of this article, the stewardship organization shall not be deemed in compliance with this article until the stewardship organization submits an annual report that the department finds compliant with the requirements of this article.

(c) The approved annual report shall be a public record, except that financial, production, or sales data reported to the department by the stewardship organization is not a public record for purposes of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1 of the Government Code) and shall not be open to public inspection. The department may release financial, production, or sales data in summary form so the information cannot be attributable to a specific producer, retailer, wholesaler, or to any other entity.

42075. *(a) A stewardship organization, as part of its stewardship plan, shall set up a trust fund or an escrow account, into which it shall deposit all unexpended funds, for use in accordance with this section in the event that the stewardship plan terminates or is revoked.*

(b) If a stewardship plan terminates or is revoked, the trustee or escrow agent of a trust fund or escrow account set up pursuant to subdivision (a) shall do both of the following, starting within 30 days:

(1) Accept payments directly from producers into the trust fund or escrow account that would have been made to the stewardship organization prior to the plan's termination or revocation.

(2) Make payments from the trust fund or escrow account as the department shall direct, in writing, to implement the most recently approved stewardship plan.

(c) If a new stewardship plan has not been approved by the department within one year after termination or revocation, the department may make modifications to the previously approved plan, as it deems necessary, and continue to direct payments from the trust fund or escrow account in accordance with paragraph (2) of subdivision (b) to implement the modified stewardship plan.

(d) A trustee or escrow agent in possession of stewardship funds shall, as directed by the department, transfer those funds to a successor stewardship organization with an approved stewardship plan.

42076. *(a) Except as provided in subdivision (c), an action specified in subdivision (b) that is taken by a stewardship organization or its members is not a violation of the Cartwright Act (Chapter 2 (commencing with Section 16700) of Part 2 of Division 7 of the Business and Professions Code), the Unfair Practices Act (Chapter 4* *(commencing with Section 17000) of Part 2 of Division 7 of the Business and Professions Code), or the Unfair Competition Law (Chapter 5 (commencing with Section 17200) of Part 2 of Division 7 of the Business and Professions Code).*

(b) Subdivision (a) shall apply to all of the following actions taken by a stewardship organization or its members:

(1) The creation, implementation, or management of a stewardship plan approved by the department pursuant to this article and the types or quantities of single-use packaging or priority single-use products managed pursuant to a stewardship plan.

(2) The cost and structure of an approved stewardship plan.

(3) The establishment, administration, collection, or disbursement of any charges associated with funding the implementation of this article.

(c) Subdivision (a) shall not apply to an agreement that does any of the following:

(1) Fixes a price of or for single-use packaging or priority single-use products, except for an agreement related to costs or charges associated with participation in a stewardship plan approved or conditionally approved by the department and otherwise in accordance with this article.

(2) Fixes the output of production of single-use packaging or priority single-use products.

(3) Restricts the geographic area in which, or customers to whom, single-use packaging or priority single-use products will be sold.

Article 5. California Circular Economy Regulatory Fee

42080. *(a) (1) The department shall establish, and a producer shall pay, a California circular economy regulatory fee. The amount of the fee shall be established and adjusted by the department based on the factors specified in paragraph (3). The department shall set this fee to collect no more than is necessary for the regulatory costs of this chapter for the following fiscal year, including a prudent reserve, as specified in subparagraph (B) of paragraph (3).*

(2) A producer shall remit the fee assessed pursuant to this subdivision to the department on a quarterly schedule for deposit into the California Circular Economy Fund, which is hereby created in the State Treasury. The revenue from the fee shall be tracked separately by the department and shall not be used for activities other than those described in this subdivision.

(3) Before establishing or adjusting the fee, the department shall review at a public hearing all of the following factors:

(A) A projection of the amount necessary to fund the reasonable regulatory costs incurred by the department incident to audits, inspections, administrative activities, adjudications, or other regulatory activities associated with single-use packaging and priority single-use products pursuant to this chapter, taking into account any revenue received from entities agreeing to corrective action plans.

(B) The sufficiency of revenues in the California Circular Economy Fund for the department to administer, enforce, and promote its regulatory activities regarding single-use packaging and priority single-use products, including the regulatory aspects of the programs established pursuant to this chapter, plus a prudent reserve.

(C) Whether additional revenues are necessary to preserve the department's ability to conduct regulatory activities in the following fiscal year.

(D) If the actual regulatory costs incurred by the department are lower than the projected costs, whether, at the end of the fiscal year, a sufficient net fund balance remains in the California Circular Economy Fund to reduce the fee.

(4) An adjustment to the fee shall become effective on January 1 of the year following its adoption.

(5) The department may adopt regulations to establish and adjust the fee. Regulations to adjust the fee shall be deemed to meet the description in subdivision (g) of Section 11340.9 of the Government Code and may be filed by the department pursuant to Section 11343.8 of the Government Code.

(b) (1) The amount of the fee imposed on a producer shall be proportionate to the cost of regulating that producer based on whether the producer is complying with this chapter individually or collectively as a member of a stewardship organization. If a producer is a member of a stewardship organization, the stewardship

organization shall be responsible for paying the fee on behalf of the producer. A stewardship organization may require a member to reimburse the stewardship organization for the amount of the regulatory fee paid on behalf of the member.

(2) The amount of the fee imposed on a producer shall be proportionate to the cost of regulating that producer based on whether the producer is a producer of single-use packaging or priority single-use products.

(3) If a fee paid by a producer pursuant to the California Beverage Container Recycling and Litter Reduction Act (Division 12.1 (commencing with Section 14500)) or any other programs relevant to this chapter results in reduced costs of regulating that producer under this chapter, the department shall account for that reduced cost of regulation when determining the amount of the California circular economy regulatory fee to impose on that producer.

(c) If the state loans money from a fund to the California Circular Economy Fund for managing single-use packaging or priority single-use products in the state, moneys in the California Circular Economy Fund may be used toward repaying a loan that was made before January 1, 2020, or any other loan of public funds made for the purposes set forth in this section.

SEC. 3. *Chapter 6 (commencing with Section 48710) is added to Part 7 of Division 30 of the Public Resources Code, to read:*

CHAPTER 6. Local Agency Regulation of Food Packaging Material

48710. *(a) For purposes of this chapter, the following definitions apply:*

(1) "Curbside program" means a recycling or composting program that picks up waste material from individual or multiple family residences, or both, with the intent to recycle or compost the waste material, operated by, or pursuant to a contract with, a local agency, or is acknowledged, in writing, by a local agency.

(2) "Grocery store" means a store primarily engaged in the retail sale of canned food, dry goods, fresh fruits and vegetables, and fresh meats, fish, and poultry, and any area that is not separately owned within the store where food is prepared and served, including a bakery, deli, and meat and seafood counter.

(3) "Local agency" means a city, county, city and county, or other local public agency.

(b) A local agency shall not require a grocery store to use a certain type of food packaging for any food sold in the grocery store unless the majority of residential households within the jurisdiction of the local agency have access to a curbside program that accepts the material from which that food packaging is made.

(c) A local agency shall not require a grocery store to use a food packaging container that does not meet an ASTM standard specification, as defined pursuant to subdivision (b) of Section 42356, or the compostability criteria developed pursuant to Section 42052.

(d) (1) Except as provided in paragraph (2), a local agency shall not enforce or implement an ordinance, resolution, regulation, or rule, or make any amendment to an ordinance, resolution, regulation, or rule, that violates or is in conflict with subdivision (b) or (c).

(2) A local agency that, as of September 15, 2019, has an ordinance, resolution, regulation, or rule that violates or is in conflict with subdivision (b) or (c) may continue to implement and enforce that ordinance, resolution, regulation, or rule.

(e) This chapter does not prohibit a local agency from requiring a grocery store to use a certain type of food packaging that is refillable or reusable.

(f) This chapter shall remain in effect only until January 1, 2030, and as of that date is repealed.

SEC. 4. *The Legislature finds and declares that Section 1 of this act, which adds Chapter 3 (commencing with Section 42040) to Part 3 of Division 30 of the Public Resources Code, imposes a limitation on the public's right of access to the meetings of public bodies or the writings of public officials and agencies within the meaning of Section 3 of Article I of the California Constitution. Pursuant to that constitutional provision, the Legislature makes the following findings to demonstrate the interest protected by this limitation and the need for protecting that interest:*

In order to protect the proprietary information of producers, retailers, and wholesalers of single-use packaging and priority single-use products, it is necessary that financial, production, and sales data reported by producers, retailers, and wholesalers of single-use packaging and priority single-use products be kept confidential.

SEC. 5. *No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs that may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, eliminates a crime or infraction, or changes the penalty for a crime or infraction, within the meaning of Section 17556 of the Government Code, or changes the definition of a crime within the meaning of Section 6 of Article XIII B of the California Constitution.*

PACIFIC FISHERY MANAGEMENT COUNCIL
Swordfish Management and Monitoring Plan
DRAFT
September 2018

1 Introduction

The Pacific Fishery Management Council (Council) manages targeting of swordfish on the West Coast under its Fishery Management Plan for West Coast Fisheries for Highly Migratory Species (HMS FMP). A variety of gears are being used to catch swordfish on the West Coast (i.e., swordfish fishery), including large drift gillnet (DGN), harpoon, pelagic longline, and deep-set buoy gear (DSBG) (See Appendix A). Pelagic longline gear cannot be used within the U.S. Exclusive Economic Zone (EEZ) of the West Coast (three to 200 nautical miles) and shallow-set longline fishing (SSLL) to target swordfish cannot be conducted both east and west of 150 degrees W. longitude. However, there is a general interest in exploring use of pelagic longline gear on the West Coast. Bycatch[1] of non-target finfish species and incidental take of protected species while targeting swordfish remains an ongoing concern for the Council because protected species, including whales, dolphins, pinnipeds (e.g., seals, sea lions), sea turtles, and seabirds have special status under Federal statutes. Therefore, the Council is required to monitor these fisheries, and reduce or minimize bycatch of these animals to the extent practicable.

Under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA), various mitigation measures that substantially reduced bycatch of protected species were instituted; however, there has also been a coincidental decline in participation in these fisheries, resulting in a decline in landings as well. In addition, West Coast fishery participants are testing other gears (e.g. DSBG) to target swordfish with minimal bycatch. These topics motivated the Council to consider the swordfish fishery with a more holistic approach. Therefore, in 2015, the Council developed a draft Swordfish Management and Monitoring Plan (SMMP) to articulate the Council's vision and future actions for the West Coast swordfish fishery as a subplan under the Council's HMS FMP.

2 Purpose of the Plan

This SMMP serves as a guide for the Council to manage the West Coast swordfish fishery based on four fishery management goals:

1. Reduce protected species bycatch to the extent practicable in the swordfish fishery through mitigation, gear innovation, and individual accountability.
2. Reduce unmarketable and prohibited finfish catch to the extent practicable in the swordfish fishery through mitigation, gear innovation, and individual accountability.
3. Support the economic viability of the swordfish fishery so that it can meet demand for a fresh, high quality, locally-caught product and reduce reliance on imported seafood.
4. Promote and support a wide range of harvest strategies for swordfish off the West Coast.

[1] The Magnuson-Stevens Act includes a definition of bycatch as fish that are discarded (not sold or kept for personal use). The Act defines "fish" broadly to cover all forms of marine life except marine mammals and seabirds. The term "take" is used in protected species statutes to refer to interactions which may or may not be lethal. For simplicity, the term bycatch will be used in this SMMP more broadly than the MSA to refer to the capture and release of all forms of marine life, including marine mammals and seabirds.

These goals will be achieved through a variety of mitigation and management measures outlined in this SMMP (See Section 3).

The Council intends to minimize non-target finfish and protected species (including sea turtles, marine mammals, and seabirds) bycatch in the West Coast swordfish fishery as a whole to be consistent with National Standard 9 and Section 303 of the Magnuson-Stevens Act to "(a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch."

The Council will continue to minimize bycatch and bycatch mortality of finfish and protected species to the extent practicable while ensuring that the West Coast swordfish fishery remains economically viable. Economic viability encompasses support for a swordfish fishery conducted by vessels with West Coast homeports and increased availability of locally-caught swordfish in the market.

In addition, the Council intends to better integrate fishery management under the HMS FMP with enhanced protection of ESA-listed species and other protected species (e.g. non-ESA-listed seabirds and marine mammals) while promoting and supporting a wide range of harvest strategies that include new or modified gear, and area management considerations.

In 2014, the Council began to consider the best method to develop this SMMP. Initially it was intended as a roadmap for transiting DGN fishery participants to the use of other gear types. But the Plan was broadened to reflect the Council's intent to look at all feasible gear types for targeting swordfish in light of a bycatch reduction goal, including DGN. In June 2014, the Council agreed on a list of policy objectives intended to guide management of the West Coast swordfish fishery with the dual goals of reducing bycatch while maintaining or enhancing its economic viability (See Agenda Item E2 and Council Decision Summary).

Elements of this Plan have appeared in Highly Migratory Species Management Team (HMSMT) Reports for the March and June 2015 Council meetings which also included alternatives and analyses for proposed actions for bycatch reduction in the DGN fishery. The Council reviewed the Plan in September 2015 and again in June and September 2018. Finalization of this Plan will not only facilitate implementation of the actions described below in Section 3, but will also provide an administrative record on the Council's vision going forward for a sustainable swordfish fishery off of the West Coast. It's intended that actions in this plan may be updated or revised by the Council in the future, as needed, to meet the fishery management goals of this SMMP.

3 Actions to Be Taken Under This Plan

A. Reduce bycatch in the DGN fishery through hard caps and performance standards

1. Consider hard caps to limit takes of loggerhead and leatherback sea turtles in the DGN fishery. For example, if a hard cap is reached or exceeded during a fishing season, or during a specified period, a specific time-area closures could go into effect.
2. Continue to review bycatch estimates against performance standards for specified marine mammals, sea turtles, and finfish. The Council may periodically review the efficacy of bycatch estimation methods used to judge performance, and the species for which performance standards are set. Based on trends of bycatch compared to specified performance standards, the Council may recommend additional management measures, as appropriate.
3. Work with NMFS to increase fishery monitoring with the goal of monitoring all vessels by means of either human observers or electronic monitoring technology. Initially, the Council desires a 30% coverage rate across all vessels. For vessels that are unobservable by humans, electronic monitoring (EM) should be used to meet the coverage rate goal.

4. In the absence of 100% monitoring, use the best available statistical methods to estimate rare event bycatch.
5. Explore the use of dynamic ocean modeling tools, such as EcoCast, as part of an individual accountability-based management strategy.[2]

B. Develop deep-set buoy gear

1. Evaluate the results of fishing under EFPs, including deep-set linked buoy gear, recommended by the Council and issued by NMFS.
2. Complete HMS FMP amendment and regulatory processes to authorize a DSBG fishery.
3. As part of fishery authorization, consider a Federal limited entry program for DSBG including qualification criteria, taking into account current participation in the West Coast swordfish fishery.

C. Limit fishing effort in the DGN fishery

1. Explore ways to leverage Federal DGN fishery limited entry permits to reduce bycatch, noting that implementation of the Federal permit may result in some natural attrition of permit holders. For example, as of June 2018, only two-thirds of state limited entry permit holders had applied for the Federal limited entry permit.
2. Determine the appropriate number of Federal limited entry permits based on the fishery management goals within this SMMP. Explore mechanisms to retire excess permits, including compensating holders for retiring permits. For example, a minimum landings requirement during some recent time-period could be required to retain a permit.
3. Explore use of the Federal limited entry permit to encourage DGN fishery participants to utilize other gear types. For example, the Federal limited entry permit regulations could be amended to include permit endorsements for other gear types such as pelagic longline and/or DSBG (if managed through limited entry) or to encourage swapping a DGN permit for a limited entry permit for another fishery/gear type.

D. Allow DGN vessels to access the PLCA

1. The Pacific Leatherback Conservation Area (PLCA) was implemented in 2001 to mitigate takes of endangered Pacific leatherback sea turtles. It covers an area of the EEZ from Monterey Bay in California to the central Oregon coast and is closed to DGN fishing each year from August 15 to November 15. Based on exempted fishing permit (EFP) performance within the PLCA, consider allowing access to the PLCA with individual vessel and/or fishery accountability for bycatch using limits such as hard caps on leatherback sea turtles.
2. Explore the use of dynamic ocean modeling tools, such as EcoCast, as part of an individual accountability based management regime that would allow DGN vessels to fish in specified areas within the boundaries of the current PLCA.

E. Develop longline fisheries

1. Revisit the 2009 proposed action to authorize a SSLL fishery outside the West Coast EEZ in light of current conditions including West Coast landings by Hawaii-permitted SSLL vessels.
2. Revisit the current FMP prohibition on the use of pelagic longline gear inside the West Coast EEZ.

[2] EcoCast is a fisheries sustainability tool that helps fishers and managers evaluate how to spatially allocate fishing effort to maintain target fish catch while minimizing bycatch of protected or threatened species.

3. Consider qualification criteria for a Federal limited entry SSLL permit in the context of Federal permitting for other swordfish gear types.
4. Explore the feasibility of, through exempted fishing permits, new pelagic longline gear designs or management strategies.

4 Road Map for Implementing Actions under this Plan

Actions related to this Plan that are included in Council's "Year-at-a-Glance" planning document (Agenda Item C.11, Supplemental Attachment 3, June 2018) are listed below. The Council may decide to supplement this section of the Plan by identifying additional actions over a longer time frame.

September 2018

1. Review updates to this Swordfish Monitoring and Management Plan
2. Consider proposed changes to the DGN performance metrics methodology

November 2018

1. Scoping of FMP amendment authorizing a SSLL fishery outside the EEZ
2. Review new proposed performance metrics based on new methodology (tentative)

March 2019

1. Adopt a range of alternatives for FMP amendment authorizing a SSLL fishery outside the EEZ
2. Final action on authorizing a DSBG fishery

June 2019

1. Adopt a preliminary preferred alternative for FMP amendment authorizing a SSLL fishery outside the EEZ
2. DGN performance metrics annual report
3. Ongoing EFP update
4. Initial EFP proposal review and recommendation

September 2019

1. Adopt a final preferred alternative for FMP amendment authorizing a SSLL fishery outside the EEZ
2. EFP proposal final recommendation

APPENDIX A

There are three commercial gear types currently used on the West Coast, in the U.S. Exclusive Economic Zone (EEZ) to harvest swordfish: drift gillnet, harpoon, deep-set buoy gear and linked deep-set buoy gear. Pelagic longline gear cannot be used within the EEZ of the West Coast (three to 200 nautical miles) and shallow-set longline fishing (SSLL, setting gear in less than 100 meters) to target swordfish cannot be conducted east and west of 150 degrees W. longitude to target swordfish. However, there is a general interest in exploring use of pelagic longline gear on the West Coast. Vessels permitted with a Hawaii longline limited access permit land on the West Coast with some vessels consistently operating from the West Coast; therefore, these swordfish landings are reported as pelagic longline. These gear types and their relevance to the West Coast swordfish fishery are summarized below. Current landings and revenue are summarized in Table 1.

Based on work by Gjertsen, et al. these four gear types can be grouped as follows: pelagic longline and DGN are capable of larger catch volume but result in relatively higher bycatch versus deep-set buoy gear and harpoon with low catch volume and little or no bycatch. Thus, the mix of gear types used in the swordfish fishery will reflect a tradeoff between the total amount of swordfish that could be landed on the West Coast, product quality, and bycatch impacts.

Table 1. Total number of vessels that made swordfish landings, metric tons of swordfish landed, inflation adjusted ex-vessel revenue ($1,000s), and inflation adjusted average price per pound, 2013-2017. (Source: PacFIN, 6/20/18)

Fishery	Total Number of Vessels	Total landings (mt)	Total Inflation Adjusted Ex-Vessel Revenue ($1,000s)	Average Inflation Adjusted Price Per Pound*
Pelagic Longline**	23	2,173	$11,362	$2.37
DGN	28	693	$4,332	$2.84
DSBG†	7	93	$962	$4.69
Harpoon	32	67	$795	$5.40

*Computed as total inflation-adjusted ex-vessel revenue divided by total landings in pounds.
**Hawaii permitted vessels.
†DSBG landings 2015-2017.

Large Mesh Drift Gillnet

- The DGN fishery began in the late 1970s and expanded in the 1980s, initially targeting thresher sharks but switching the principal target to swordfish after the mid-1980s.
- Landings and participation peaked in the mid-1980s and have been steadily declining since that time.
- Fishing occurs mainly in the fall and winter; the fishery is closed February 1-April 30. Little if any fishing occurs May 1-August 14 when fishing is prohibited within 75 nm from the mainland shore.
- Landings averaged 139 mt for calendar years 2013-2017 (Table 1) while participation averaged 19 vessels per year.
- Takes of leatherback sea turtles and large whales are of particular concern in this fishery. Other marine mammal species are caught in this fishery.
- Take/bycatch mitigation measures have been implemented for this fishery under the HMS FMP, the ESA, and the MMPA. These include gear modifications (pingers and net extenders) and time-area closures. The PLCA is the largest time-area closure, covering waters from Monterey north, August 15 to November 15 each year.

- Based on Council and NMFS action, Federal DGN limited entry permit was implemented in 2018. This permit, in addition to the California LE DGN permit, is required to fish with DGN in Federal waters and land in California. All current California LE DGN permit holders are eligible to apply for, and receive, a Federal LE DGN permit. State permit-holders have until March 31, 2019, to obtain their Federal permits, and three months after that to appeal if they miss the deadline. If any permit holder does not obtain their Federal permit by this deadline, they will lose their opportunity to do so, subject to any decisions resulting from an appeal process. The state LE DGN permit alone will not authorize harvest and landing of swordfish with DGN.

Harpoon

- Harpoon gear is used to catch swordfish while they are basking on the surface during the day and generally requires calm sea conditions to be effective.
- Most fishing occurs in the summer months, when environmental conditions are favorable.
- Because it is a highly selective gear, harpoon is effectively free of non-target catch. However, swordfish do occasionally break free and their fate is unknown.
- This is a low volume fishery with a higher ex-vessel price per pound for swordfish compared to DGN and SSLL (Table 1). Because of the operating costs and low volume, this fishery is not usually the sole source of income for participants. In the five years 2013-2017, landings averaged 13 mt annually (Table 1). Participation averaged 15 vessels annually, 2013-2017, with a total of 32 unique vessels making landings during this period (Table 1).

Standard Deep-Set Buoy Gear (DSBG) and Linked Deep-Set Buoy Gear (LBG)

- The Pfleger Institute of Environmental Research (PIER) began design and testing of DSBG off the West Coast in 2011. In 2015, based on the Council recommendation, NMFS issued exempted fishing permits to PIER to allow cooperative fishers to test the commercial viability of the gear under PIER's supervision.
- Between 2015 and 2017, seven vessels landed a total of 93 mt of swordfish under these EFPs (Table 1).
- Standard DSBG is deployed during daytime using a vertical line suspended from a buoy with hooks set deep. Weight on the terminal end of the vertical line ensures a rapid sink rate to the desired depth. A strike indicator and active tending allows catch to be retrieved quickly, reducing bycatch mortality. The configuration is limited to no more than 10 pieces of gear to allow active tending. These characteristics are intended to minimize bycatch and bycatch mortality, especially of protected species.
- This gear is expected to complement/supplement harpoon gear, because of its similarity in terms of vessel requirements, catch volume, and high product price.
- PIER also developed and in 2016 trialed LBG. LBG has the same characteristics as the standard configuration in terms of setting deep during the daytime to avoid bycatch and strike detection to allow quick retrieval. With the LBG configuration, up to three hooks are deployed along a horizontal line set at depth between two vertical lines suspended from floats in the same fashion as the standard configuration. Up to 10 of these pieces are then linked by horizontal lines that allow each piece to be independently retrieved.
- LBG is intended to produce larger catch volume from larger vessels and thus could complement or supplement DGN.
- Between June 2016 and March 2018, the Council reviewed more than 50 EFP applications to test these gear types and made recommendations to NMFS on issuance. NMFS began issuing EFPs based on Council recommendations in the summer of 2018.

Pelagic Longline

- Shallow-set longline (SSLL) gear is distinguished by the deepest point of the main line set at depths shallower than 100 m.
- Sea turtle takes (specifically loggerhead and leatherback sea turtles) have been a focus of concern with this gear type but the use of large circle hooks and mackerel type bait has been shown to substantially reduce takes, serious injuries, and mortality.
- Seabird interactions are also a concern with all types of longline gear. Seabird mitigation measures for pelagic longline gear are required in Federal regulations (see 660 CFR 712(c).
- SSLL vessels were operated seasonally and intermittently from West Coast ports until 2004.
- SSLL is currently prohibited under the HMS FMP and ESA regulations.[3]
    - Pelagic longline is prohibited in the West Coast EEZ (50 CFR 660.712(a)(1))
    - SSLL is prohibited west of 150°W longitude and north of the equator (50 CFR 660.712(a)(2)).
    - SSLL is prohibited east of 150°W longitude and north of the equator under ESA regulations (50 CFR 223.206(d)(9))
- In partially disapproving the SSLL provisions in the HMS FMP, NMFS encouraged the Council to consider an FMP amendment to require circle hooks/mackerel type bait and a limited entry program in order to authorize a SSLL fishery addressing ESA concerns.
- The Council last considered authorizing an SSLL fishery in 2009 but decided not to move forward because of bycatch concerns.
- Hawaii-permitted SSLL vessels that fish outside the EEZ are allowed to make landings on the West Coast.
- In the five years 2013-2017, a total of 23 Hawaii permitted vessels annually averaged 435 mt of swordfish landings to the West Coast effectively making it the largest swordfish fishery on the West Coast by volume and revenue (Table 1).
- Hawaii-permitted SSLL landings on the West Coast mostly occur between November and March when swordfish are more abundant in waters closer to the West Coast than to Hawaii.

[3] Hawaii-permitted SSLL vessels are not subject to these prohibitions except for fishing inside the West Coast EEZ.

NATIONAL MARINE FISHERIES SERVICE (NMFS) REPORT ON THE SWORDFISH MANAGEMENT AND MONITORING PLAN (SMMP)

Following review of Agenda Item H.6, Attachment 1: Pacific Fishery Management Council (Council) Draft Swordfish Management and Monitoring Plan (SMMP), NMFS offers some comments for the Council and its advisory bodies to take into account when reviewing and adopting a draft SMMP for public review. These comments specifically pertain to *Section 3: Actions to be Taken Under This Plan* and *Section 4: Road Map for Implementing Actions Under this Plan*. Below, NMFS addresses Actions listed in the SMMP and updates to the Road Map in Section 4. Appendix A includes an annotated list of the Actions identified in Section 3, as well as the Measures listed therein, and relates them to the agenda items listed in Section 4. NMFS notes that some Measures have cross-cutting goals that may be addressed in tandem.

Action A. Reduce Bycatch in the Drift Gillnet (DGN) fishery

NMFS offers a few comments and updates regarding the bycatch estimation methodology for the DGN fishery, as well as continued Council evaluation and recommendations related to the performance of the DGN fishery. As stated in previous NMFS reports (e.g., Supplemental NMFS Report 1 G.7.a, June 2018), NMFS maintains that the regression tree method produces the best scientific information available (BSIA) for estimating rare-event bycatch. Regardless of the outcomes of the Science and Statistical Committee (SSC)'s review of the regression-tree method, NMFS plans to continue using this method for estimating DGN bycatch for the purposes of completing marine mammal stock assessment reports. NMFS has determined that the regression-tree methodology accurately estimates rare-event bycatch by incorporating data from multiple fishing seasons, instead of relying on the smaller number of sets used in single-season ratio estimates. The forthcoming bycatch estimates based on the regression tree method will incorporate data from over 9,000 observed sets over 28 seasons. Further, the ongoing work of the Eastern Pacific Professional Specialty Group (EP PSG) to integrate fishery data from multiple sources should also improve these estimates (e.g., by providing a better understanding of the timing and location of unobserved fishing effort). If, during annual reporting of DGN performance, the Council identifies a need for performance management measures, NMFS expects that the Council would add consideration of such recommendations to a future meeting agenda, as opposed to recommending new management measures at a single Council meeting.

On June 20, 2018, the Council notified the NMFS West Coast Region (WCR) Regional Administrator of its preferred alternative for increasing monitoring in the DGN fishery and its interest in receiving updates on proposed and ongoing initiatives to enhance DGN fishery monitoring. As reported in June, the WCR Observer Program has submitted a Fisheries Information System Program proposal to place flywire electronic monitoring systems on DGN vessels for the 2019 season. The results of the proposal should be announced over next few months. Additionally, NMFS plans to re-assess all unobservable DGN vessels this year to evaluate potential observability. If a vessel can make changes to accommodate an observer, NMFS will request that those changes be made. However, bunk space and vessel safety issues are likely to continue to result in classifying some vessels as unobservable. Additionally, the EP PSG has made progress this year on integrating observer data, logbooks, landings, and vessel monitoring system

(VMS) data from the DGN fishery. This integrated data is being used to assess potential observer bias (i.e., differences in fishing practices between observed and unobserved sets). The results of this work will be incorporated into the new Biological Opinion for the DGN fishery. If gaps in coverage which are likely to increase bycatch risk are identified, observer placement and deployment may be modified. NMFS will continue to keep the Council informed on these developments via NMFS Reports. Therefore, NMFS does not see a need to add Council discussion of Measures related to DGN monitoring to the Road Map in the SMMP, or to the Council's Year-At-A Glance Summary (YAG), at this time.

Lastly, NMFS seeks clarity on the Council's interest in considering hard caps for loggerhead and leatherback sea turtles. It is unclear whether this Measure should be viewed independent of, or in relation to, either the performance monitoring Measure or the Action to allow DGN vessels to access the Pacific Leatherback Conservation Area (PLCA). Additionally, the Council could clarify whether it is considering a revision to the withdrawn hard caps proposed rule (i.e., an effort to make the proposed regulations consistent with the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Fishery Management Plan (FMP), and other applicable laws). A better understanding of the Council's interest in this measure would be useful in considering whether the hard cap Measure should appear on the Road Map.

Action B. Develop Deep-set Buoy Gear (DSBG)

NMFS has issued approximately 20 deep-set buoy gear (DSBG), and 10 deep-set linked buoy gear (DSLBG) exempted fishing permits (EFPs). Issuance and activation of some EFPs are pending as applicants either have not yet signed the permits, or have not attended the required protected species workshop. All vessels that requested Observer Program inspections have been inspected. Additional protected species workshops are tentatively scheduled for August 31 and September 7, 2018. See Table 1 below for additional information on EFP activity to-date.

Table 1. Information on DSBG and LBG EFPs in 2018 As of August 27, 2018

Metric	DSBG	LBG
Vessels fished so far in 2018	12	0
Number of Trips Observed	38	0
Number of Fishing Days Observed	154	0
Protected Species Interactions	1 Northern Elephant Seal - Released Alive 1 Loggerhead Sea Turtle* - Released Alive (Entangled in Surface Gear)	N/A

*The loggerhead sea turtle interaction consisted of a turtle entangled in surface buoy array lines. NMFS is currently reviewing the information from the interaction and discussing the likelihood of additional interactions.

NMFS is concerned about the adequacy of Council discussions to-date regarding the range of alternatives (ROA) for authorizing deep-set buoy gear. At this time, the Council has yet to adopt alternatives for qualifying criteria for the limited entry (LE) options being considered, which is critical for completing a thorough NEPA analysis and documenting necessary considerations under MSA Section 303(b)(6) of the MSA. Consistent with previous requests (e.g. Agenda Item C.5.a., Supplemental NMFS Report), NMFS encourages the Council to schedule its adoption of a preliminary or final preferred alternative (PPA or FPA) two meetings following adoption of the Council's final ROA, to leave adequate time for an analysis of the alternatives. Additionally, NMFS encourages the Council to specify the need for a LE approach to DSBG authorization and to identify qualification criteria for the LE options in the ROA adopted during the June 2018 meeting, prior to Council selection of an FPA (especially selection of a LE option). It may be possible to complete these steps prior to March 2019, when the FPA is scheduled. The HMSMT identified and the HMSAS commented on potential qualifying criteria in previous reports to the Council (see Agenda Item H.3.a, HMSMT Report , Agenda Item J.6.a, HMSMT Report 1, and J.6.a, Supplemental HMSAS Report 1). However, delaying Council selection of an FPA until more data is obtained from the recently issued DSBG and DSLBG EFPs may also help to further inform an evaluation of the ROA and Council discussion of qualifying criteria for LE options.

Action C. Limit Fishing Effort in the DGN Fishery

Now that the federal LE DGN permit program has been created, the Council can consider additional measures for limiting effort in the fishery. However, Council discussion of this has yet to be added to the Council's YAG or Road Map in Section 4 of the SMMP. Given the cross-cutting nature of some of the Measures identified under this Action (e.g., incentivizing use of non-DGN gear or compensating DGN permit holders for retiring permits), it would be useful to scope potential changes to the federal LE permit program (i.e., currently for DGN) prior to a Council recommendation to establish a LE program for another gear type. This could help streamline Council recommendations on multiple Measures, as well as NMFS's implementation workload.

D. Allow DGN Vessels to Access the PLCA

NMFS intends to keep the Council updated on the status of the Alliance of Communities for Sustainable Fisheries' (ACSF) application to fish with modified DGN gear in the PLCA. However, NMFS cannot recommend a timeframe for Council consideration of allowing DGN vessels access to the PLCA. As stated in Agenda Item G.7.a, Supplemental NMFS Report 1, NMFS will communicate further with the ACSF regarding concerns with their EFP application, as raised by NMFS Protected Resources Division. It is unclear at this time whether this EFP can be issued.

E. Develop Longline Fisheries

Both the Road Map in Section 4 of the SMMP and the Council's YAG call for revisiting authorization of shallow-set longline (SSLL) on the high seas. As conveyed during the June meeting, NMFS is prepared to support the Council in evaluating alternatives for this Measure. NMFS can also assist in coordination with the Pacific Islands region or Western Pacific Regional Fishery Management Council or both. NMFS has repeatedly requested that scoping for this Measure appear on the Council's November meeting agenda, so that interested stakeholders (many of whom are based in southern California) can travel to the meeting in San Diego.

Despite our interest in starting these Council discussions in November, NMFS regards the current schedule for Council discussion of this Measure as aggressive. Rather, NMFS would like to see more meeting time given to developing a ROA for analysis. Experience indicates that one Council meeting has been insufficient time for developing a final ROA, especially when the ROA includes LE options. Similar to requests for scheduling the Measure to authorize DSBG, NMFS would like to see the final ROA and PPA for this Measure scheduled two meetings apart, to provide adequate time for analysis of the alternatives.

With respect to authorizing longline gear in the U.S. West Coast exclusive economic zone (EEZ), NMFS expects that results from the longline EFPs currently in consideration would help inform Council discussion. It may be useful to include testing of longline EFPs as a specific Measure in the SMMP (as is the case for DSBG).

Appendix A. Road Map as proposed in Agenda Item H.6., Attachment 1: Council's Draft Swordfish Management and Monitoring Plan (SMMP)					
Short Description of Actions and Measures in Section 3 of SMMP	**Sept. 2018**	**Nov. 2018**	**Mar. 2019**	**Jun. 2019**	**Sept. 2019**
A. Reduce bycatch in DGN fishery					
1. Consider hard caps for loggerheads & leatherbacks					
2. Continue to monitor bycatch against performance standards. Review estimation methods. Council may recommend measures based on trends.		Review perf. metrics based on new methodology		Review perf. metrics (annual report)	
3. Target 30% coverage for all vessels; increase monitoring with goal of monitoring all vessels through observers or EM					
4. In absence of 100 % monitoring, use best available statistical methods to estimate rare-event bycatch	Consider changes to perf. metrics methodology				
5. Explore DOM, such as EcoCast, as part of individual accountability strategy					
B. Develop DSBG					
1. Evaluate results of EFPs, including DSLBG				Ongoing EFP update & Initial EFP review/ recommendation	EFP proposal final recommendation
2. Complete FMP amendment and regulatory process to authorize DSBG			FPA to authorize DSBG fishery		
3. As part of authorization, consider a LE for DSBG, including qualifying criteria					
C. Limit fishing effort in DGN fishery					
1. Explore ways to leverage Fed LE permits to reduce bycatch, noting natural attrition may occur					
2. Determine # of LE permits based on goals within SMMP. Explore retiring excess permits, including compensating permit holders					
3. Explore use of LE permits to encourage DGN participants to use other gear types, such as gear endorsements or swapping DGN for an another gear type					
D. Allow DGN vessels access to the PLCA					
1. Based on EFP performance within PLCA, consider allowing access to the PLCA with accountability for bycatch using limits (e.g., hard caps for leatherbacks)					
2. Explore use of DOM tools as part of individual accountability regime to allow DGN vessels to fish within the boundaries of the PLCA					
E. Develop longline fisheries					
1. Revisit proposed action to authorize SSLL fishery on the high seas		Scoping to authorize SSLL on high seas	ROA to authorize SSLL on high seas	PPA to authorize SSLL on high seas	FPA to authorize SSLL on high seas
2. Revisit current FMP prohibition on use of longline gear in West Coast EEZ					

California Fish and Game Commission Tribal Committee

Work Plan: Topics and Timeline for Items Referred to TC from FGC

Updated September 2019

Topic	Type / Lead	Goal(s)	2019		2020 *
			Jun	Oct	Jan
			Redding	San Diego	Los Angeles
Special Projects					
Co-management	TC Project	Develop a definition for co-management	X	X	X
Tribal advisory body	TC Project	Explore options for an advisory body to provide input to TC co-chairs	X/R		
Regulatory/Legislative					
Kelp and algae harvest management regulations	DFW Project and Regulation Change	Updates; then recommendation and guidance	X	X/R	
Simplification of statewide inland fishing regulations	DFW Project and Regulation Change	Updates; then recommendation and guidance	X	X	X
Operating principles/practices and add TC to FCG meeting procedures	Regulation Change	Amend Section 665, Title 14, California Code of Regulations	X	X/R	
DFW-managed lands	DFW Project and Regulation Change	Amend Section 550, 550.5, and 551, Title 14, California Code of Regulations	X	X/R	
Developing Management Issues					
FGC climate policy	FGC Policy	During development of a policy for FGC, make recommendations and provide guidance			
Coastal fishing Communities Project	MRC Project	Updates and guidance	X	X	X
Management Plans					
Sheep, deer, antelope, trout, abalone, kelp/seaweed	DFW	Updates and guidance (timing as appropriate for each plan)	X	X	X
Informational Topics					
Poseidon, a web-based data collection and analysis tool	The Nature Conservancy	Learn more about a new tool under development to aid in data collection and analysis for harvested species		X	
Status of abalone in California	DFW	Update			
Commercial seaweed and kelp harvest	DFW	Understand current levels of commercial kelp and seaweed harvest (how much, which species, where, etc.)			
Kelp recovery efforts	DFW	Update (as requested)			
Studies of pinnipeds and California's fisheries	DFW	Understand what studies have been conducted on pinnipeds, how they affect California's fisheries, and options for addressing impacts			
Cross-pollination with MRC and WRC	FGC Committee Coordination	Identify tribal concerns and common themes with WRC and MRC	X	X	X
Annual tribal planning meeting for coordination and consultation, pursuant to Commission’s tribal consultation policy	FGC Policy	(1) Share anticipated regulatory and policy topics to be considered this year, (2) identify tribal priorities from within topics, (3) develop collaborative interests, (4) contribute to planning logistics for annual meeting, and (5) review progress on topics discussed at annual meeting.	X	X	X
Marine Protected Areas Statewide Leadership Team	OPC Project	Update on tribal participation in the Marine Protected Areas Statewide Leadership Team and implementation of the leadership team work plan	X	X	X
Proposition 64 (cannabis)	DFW/LED	Update on implementation (as requested)	X		
Wildfire impacts and state response	DFW	Update (as requested)	X		
FGC regulatory calendar	FGC	Update	X	X	X

X = Discussion scheduled   X/R = Discussion with recommendation developed and moved to FGC

FGC = California Fish and Game Commission   TC = FGC's Tribal Committee
MRC = FGC's Marine Resources Committee   WRC = FGC's Wildlife Resources Committee
DFW = California Department of Fish and Wildlife   LED = DFW's Law Enforcement Division

STATE OF CALIFORNIA
Gavin Newsom, Governor

Fish and Game Commission

Wildlife Heritage and Conservation

Since 1870

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TRIBAL COMMITTEE

Committee Co-Chairs: Commissioner Hostler-Carmesin and Commissioner Silva

Revised* Meeting Agenda
October 8, 2019, 12:00 p.m.

*This agenda is revised to add information about and instructions for participating in the meeting via webinar or teleconference.

Participate in Person

Rincon Government Center, One Government Center Lane
Valley Center, CA 92082

Participate via Webinar

Link Here to Join the Webinar
Or, copy and paste this URL into your Internet browser:
https://cawildlife.webex.com/cawildlife/j.php?MTID=m2a0707d04fc4b05c6468bcdeaa503891

If you join the webinar using the **desktop** version of WebEx, you will be able to use your computer camera and speakers to participate in the meeting.

If you use the **web-based** version of WebEx, you will only be able to listen to the meeting; in order to actively participate in the meeting conversations, you must also call into the meeting using the phone number below.

Participate via Teleconference

Call (877) 402-9753 or (636) 651-3141; access code 832 4310

This meeting will be audio-recorded.

NOTE: **Please see important meeting procedures and information at the end of the agenda. Unless otherwise indicated, the California Department of Fish and Wildlife is identified as Department.** All agenda items are informational and/or discussion only. The Committee develops recommendations to the Commission but does not have authority to make policy or regulatory decisions on behalf of the Commission.

Call to order

1. Consider approving agenda and order of items

2. General public comment for items not on the agenda

The Committee may not discuss or take action on any matter raised during this item, except to consider whether to recommend that the matter be added to the agenda of a future meeting. [Sections 11125, 11125.7(a), Government Code]

3. Co-management definition

Discuss a co-management definition as follow-up to the co-management vision statement adopted by the Commission.

4. Kelp and algae commercial harvest regulations

Discuss tribal interests related to potential regulation changes for commercial kelp and algae harvest.

5. Committee recommendations for Commission meeting procedures

Discuss and consider approving recommendations for changes to Commission meeting procedure regulations related to the Committee.

6. Department-managed lands regulations

Receive Department overview of proposed changes to public use on Department-managed lands regulations and potential Committee recommendation.

7. Statewide inland fishing regulations

Receive Department update on efforts to develop simplified statewide inland fishing regulations.

8. Annual tribal planning meeting

Discuss potential topics for 2020 Commission tribal planning meeting held annually pursuant to the Commission's Tribal Consultation Policy.

9. Staff and other committee updates

Commission staff will highlight items of note since the last Committee meeting.

(A) Executive director
(B) Marine Resources Committee
(C) Wildlife Resources Committee

10. Agency updates

Other state agencies will highlight items of note since the last Committee meeting.

(A) Department, including potential updates from Law Enforcement Division, Fisheries Branch, Wildlife Branch, and Marine Region
(B) Other

11. Future agenda items

(A) Review work plan agenda topics and timeline
(B) Potential new agenda topics for Commission consideration

Adjourn

California Fish and Game Commission
2019 and 2020 Meeting Schedule

Note: As meeting dates and locations can change, please visit www.fgc.ca.gov for the most current list of meeting dates and locations.

2019			
Meeting Date	**Commission Meeting**	**Committee Meeting**	**Other Meetings**
November 5		**Marine Resources** Natural Resources Building 12th Floor Conference Room 1416 Ninth Street, Room 1206 Sacramento, CA 95814	
December 11-12	Natural Resources Building Auditorium, First Floor 1416 Ninth Street Sacramento, CA 95814		

2020			
Meeting Date	**Commission Meeting**	**Committee Meeting**	**Other Meetings**
January 16		**Wildlife Resources** Los Angeles area	
January 17		**Tribal** Los Angeles area	
February 5-6	Natural Resources Building Auditorium, First Floor 1416 Ninth Street Sacramento, CA 95814		
March 17		**Marine Resources** Justice Joseph A. Rattigan Building Conference Room 410 (4th Floor) 50 D Street Santa Rosa, CA 95404	
March 18			**Annual Tribal Planning Meeting** Justice Joseph A. Rattigan Building Conference Room 410 (4th Floor) 50 D Street Santa Rosa, CA 95404
April 15-16	Natural Resources Building Auditorium, First Floor 1416 Ninth Street Sacramento, CA 95814		

2020			
Meeting Date	**Commission Meeting**	**Committee Meeting**	**Other Meetings**
May 14	**Teleconference** Santa Rosa, Sacramento, Arcata, and San Diego		
May 14		**Wildlife Resources** Justice Joseph A. Rattigan Building Conference Room 410 (4th Floor) 50 D Street Santa Rosa, CA 95404	
June 24-25	Santa Ana area		
July 21		**Marine Resources** San Clemente area	
August 18		**Tribal** Fortuna area	
August 19-20	Fortuna area		
September 17		**Wildlife Resources** Natural Resources Building Redwood Room, 14th Floor 1416 Ninth Street Sacramento, CA 95814	
October 14-15	Elihu M Harris Building Auditorium 1515 Clay Street Oakland, CA 94612		
November 9		**Tribal** Monterey area	
November 10		**Marine Resources** Monterey area	
December 9-10	San Diego area		

OTHER 2019 and 2020 MEETINGS OF INTEREST

Association of Fish and Wildlife Agencies

- March 8-13, 2020, Omaha, NE
- September 13-16, 2020, Sacramento, CA

Pacific Fishery Management Council

- November 13-20, 2019, Costa Mesa, CA
- March 3-9, 2020, Rohnert Park, CA
- April 3-10, 2020, Vancouver, WA
- June 11-18, 2020, San Diego, CA

- September 10-17, 2020, Spokane, WA
- November 13-20, 2020, Garden Grove, CA

Pacific Flyway Council
- March 10, 2020 (location TBD)
- August 2020 (date/location TBD)

Western Association of Fish and Wildlife Agencies
- January 9-12, 2020, Monterey, CA
- July 9-14, 2020, Park City, UT

Wildlife Conservation Board
- November 21, 2019, Sacramento, CA
- 2020 (dates/locations TBD)

IMPORTANT COMMITTEE MEETING PROCEDURES INFORMATION

Welcome to a meeting of the California Fish and Game Commission's Tribal Committee. The Committee is chaired by up to two Commissioners; these assignments are made by the Commission.

The goal of the Committee is to allow greater time to investigate issues before the Commission than would otherwise be possible. Committee meetings are less formal in nature and provide for additional access to the Commission. The Committee follows the noticing requirements of the Bagley-Keene Open Meeting Act. It is important to note that the Committee chairs cannot take action independent of the full Commission; instead, the chairs make recommendations to the full Commission at regularly scheduled meetings.

The Commission's goal is the preservation of our heritage and conservation of our natural resources through informed decision making; Committee meetings are vital in developing recommendations to help the Commission achieve that goal. In that spirit, we provide the following information to be as effective and efficient toward that end. Welcome, and please let us know if you have any questions.

PERSONS WITH DISABILITIES

Persons with disabilities needing reasonable accommodation to participate in public meetings or other Commission activities are invited to contact the Reasonable Accommodation Coordinator at (916) 651-1214. Requests for facility and/or meeting accessibility should be received at least 10 working days prior to the meeting to ensure the request can be accommodated.

SUBMITTING WRITTEN MATERIALS

The public is encouraged to attend Committee meetings and engage in the discussion about items on the agenda; the public is also welcome to comment on agenda items in writing. You may submit your written comments by one of the following methods (only one is necessary): **Email** to fgc@fgc.ca.gov; **mail** to California Fish and Game Commission, P.O. Box 944209, Sacramento, CA 94244-2090; **deliver** to California Fish and Game Commission, 1416 Ninth Street, Room 1320, Sacramento, CA 95814; or **hand-deliver to a Committee meeting.**

COMMENT DEADLINES

The **Comment Deadline** for this meeting is **noon on October 4, 2019.** Comments received by this deadline will be made available to Commissioners. After this deadline, written comments may be delivered in person to the meeting – please bring five (5) copies of written comments to the meeting.

The Committee **will not** consider comments regarding proposed changes to regulations that have been noticed by the Commission. If you wish to provide comment on a noticed item, please provide your comments during Commission business meetings, via email, or deliver to the Commission office.

Note: Materials provided to the Committee may be made available to the general public.

REGULATION CHANGE PETITIONS

As a general rule, requests for regulatory change need to be redirected to the full Commission and submitted on the required petition form, FGC 1, titled “Petition to the California Fish and Game Commission for Regulation Change” (Section 662, Title 14, CCR). However, at the Committee’s discretion, the Committee may request that staff follow up on items of potential interest to the Committee and possible recommendation to the Commission.

SPEAKING AT THE MEETING

Committee meetings operate informally and provide opportunity for everyone to comment on agenda items. If you wish to speak on an agenda item, please follow these guidelines:

1. Raise your hand and wait to be recognized by the Committee chair or co-chair(s).
2. Once recognized, please begin by giving your name and affiliation (if any) and the number of people you represent.
3. Time is limited; please keep your comments concise so that everyone has an opportunity to speak.
4. If you would like to present handouts or written materials to the Committee, please provide five copies to the designated staff member just prior to speaking.
5. If speaking during general public comment, the subject matter you present should not be related to any item on the current agenda (public comment on agenda items will be taken at the time the Committee members discuss that item). As a general rule, general public comment is an opportunity to bring matters to the attention of the Committee, but you may also do so via email or standard mail. At the discretion of the Committee, staff may be requested to follow up on the subject you raise.

VISUAL PRESENTATIONS/MATERIALS

All electronic presentations must be submitted by the **Comment Deadline** and approved by the Commission executive director before the meeting.

1. Electronic presentations must be provided by email or delivered to the Commission on a USB flash drive by the deadline.
2. All electronic formats must be Windows PC compatible.
3. It is recommended that a print copy of any electronic presentation be submitted in case of technical difficulties.
4. A data projector, laptop and presentation mouse will be available.

LASER POINTERS may only be used by a speaker during a presentation.

STATE OF CALIFORNIA
Gavin Newsom, Governor

Fish and Game Commission

Wildlife Heritage and Conservation
Since 1870

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WILDLIFE RESOURCES COMMITTEE

Committee Co-Chairs: Commissioner Burns and President Sklar

September 10, 2019 Meeting Summary

Following is a summary of the Wildlife Resources Committee (WRC) meeting as prepared by staff. An audio recording of the meeting may be accessed online at www.fgc.ca.gov/meetings.

Call to order

The meeting was called to order at 8:46 a.m. by Commissioner Burns at the Justice Joseph A. Rattigan Building, Conference Room 410, 50 D Street, Santa Rosa, CA 95404. Commissioner Burns gave welcoming remarks.

Wildlife Advisor Ari Cornman gave welcoming remarks and outlined meeting procedures and guidelines for participating in Committee discussions, noting that the Committee is a non-decision-making body that provides recommendations to the California Fish and Game Commission (Commission) on wildlife and inland fisheries items. He introduced Commission and California Department of Fish and Wildlife (Department) staff. The following Committee member(s), and Commission and Department staff, attended:

Committee Co-Chairs

Russell Burns	Present
Eric Sklar	Present

Commission Staff

Melissa Miller-Henson	Executive Director
Ari Cornman	Wildlife Advisor
Craig Castleton	Associate Government Program Analyst

Department Staff

Kari Lewis	Chief, Wildlife Branch
Kevin Shaffer	Chief, Fisheries Branch
Patrick Foy	Captain, Law Enforcement Division
Brad Burkholder	Environmental Program Manager, Wildlife Branch
Nathan Graveline	Senior Environmental Scientist (Supervisor), Wildlife Branch
Kristin Denryter	Senior Environmental Scientist (Specialist), Wildlife Branch
Karen Mitchell	Senior Environmental Scientist (Specialist), Fisheries Branch

1. Approve agenda and order of items

The Committee approved the agenda but stated that the order of items may be altered to accommodate the arrival time of certain Department personnel and stakeholders. For purposes of the meeting summary, items are listed in the order of the published agenda.

2. Public comment for items not on the agenda

An individual provided comment about a lack of trust in public agencies.

A representative of the Nor-Cal Guides and Sportsmen's Association (NCGASA) spoke about tribal enforcement of a half-mile ban on fishing along the Klamath River at the confluence with Blue Creek, and asked the Department and Commission to look into the situation. The representative also communicated concern about inland river salmon fishing for the year not being as successful as had been hoped.

3. Department updates

(A) *Fisheries Branch*

Kevin Shaffer emphasized that the only online location to safely buy hunting and fishing licenses is at the Department's website. He also stated that California Natural Resource Agency and Department priorities include climate change and biodiversity; along those lines, the Department will bring a presentation on connectivity to a future WRC meeting.

Kevin indicated that the Department's Service Based Budgeting Project continues at a rapid pace. Recommendations from the Department's Hunting and Fishing Recruitment, Retention and Reactivation Program (R3) work groups will be released soon; California is being viewed as a leader in R3 efforts.

(B) *Law Enforcement Division*

Patrick Foy explained that this year was the first dove season opener under the new lead-free ammunition laws. Hunters that had the most success were the ones who prepared and tested their non-lead ammunition well in advance, and hunter success appeared to be relatively average. Wildlife officers did issue some citations on opening day. Co-chair Sklar asked whether there were provisions for turning in old lead ammunition, and Patrick answered that lead ammunition could still be used at shooting ranges.

Patrick also reviewed dispositions of certain abalone cases to demonstrate why wildlife cases can often take a great deal of time.

Discussion

A commenter asked about the rate of poacher apprehension and moving wardens from the coast; Patrick explained that resources are often shifted to where they are most needed at different times. Co-chair Sklar suggested the commenter speak to the state legislature about providing more money for wildlife officers and explained that the officers work for the Department rather than the Commission.

(C) *Wildlife Branch*

Brad Burkholder introduced Nathan Graveline and Kristin Denryter, new employees in the Department's Big Game Program. He also stated that the summer field season was coming to a close.

4. Initial recommendations for 2020-21 regulations

Upland game bird hunting: Brad Burkholder presented on the status of upland game birds, including declines in sage grouse and pheasant, research on mourning dove and sage grouse, and upland game bird planning efforts. The Department is not proposing any changes to upland game bird regulations for the 2020-21 season.

Discussion

Co-chair Sklar asked Brad if climate change had been taken into account when deciding how and what species of native grasses to plant in the Department's habitat restoration efforts. Brad said the Department starts with the native historical composition, but also takes into account resilience for future environmental changes.

A stakeholder stated that the issue of turkey shooting times is not a current focus, but that stakeholders may ask the Department to reassess the topic at some point. Another stakeholder asked about upland game bird funding, and Brad recounted different funding sources available for upland game bird research and management, noting that some modern land use changes have resulted in losses of bird food and habitat.

No action was taken.

5. Committee recommendations for 2020-21 regulations

(A) *Mammal hunting*

Brad Burkholder presented on deer population studies, bighorn sheep tag quotas and disease considerations, and elk tag quotas and zones. The Department is recommending some changes to mammal regulations this year, though specific numbers are dependent on data and survey results and were not yet available at the time of the meeting.

Discussion

A stakeholder asked about camera trapping by the Rocky Mountain Elk Foundation, and Brad responded that the data from that study is still being processed and considered.

Another stakeholder asked about hunter opportunities associated with elk at Point Reyes National Seashore. Brad explained that the Department has tried to encourage hunting opportunities at Point Reyes but has been met with resistance. The Department has a long-standing policy of not allowing elk translocations off the property due to disease issues.

(B) *Waterfowl hunting*

Brad Burkholder discussed proposals associated with veteran and active military hunt days, a falconry-only season, the upcoming season days, other minor regulatory proposals, and an upcoming hunter survey.

Discussion

A stakeholder asked how the Department plans to distribute the hunter survey; Brad and Kari Lewis discussed plans to inform current waterfowl hunters and to direct them to an online survey. A representative for the California Waterfowl Association asked to review the questions in advance, and a stakeholder added that there may be other groups that would like to review the questions as well. Co-Chair Sklar asked that the Department release the survey as soon as possible.

A stakeholder reminded the Department and WRC that a commitment was made to consider falconry-only days. Co-Chair Sklar suggested the idea of apportioning different hunting groups (veterans, youth, falconry, etc.) into different areas. A stakeholder pointed out that falconers generally hunt in different habitat than typical firearm waterfowl hunters. Another stakeholder suggested that some youth may derive a benefit from being "teamed up" with veteran hunters.

(C) *Central Valley sport fishing*

Kevin Shaffer presented on the status of salmon in the Central Valley and stated that recommendations would be fairly typical this year. As has been done previously, the Department will propose options to allow flexibility based on forthcoming information and changing conditions, such as drought.

Discussion

Co-Chair Sklar stated that dam removal would allow for an interesting experiment for comparisons to non-removal areas.

An NCGASA representative asked that the Department consider an extension of the salmon season on the Sacramento River for two weeks, and a representative of Coastside Fishing Club supported the comment.

(D) *Klamath River Basin sport fishing*

Kevin Shaffer presented on the Pacific Fishery Management Council process and discussions with tribes regarding salmon. He noted that the upcoming rulemaking package will provide the data for, and an explanation of, how the Department calculates its size recommendations for salmon. The Department will recommend a doubling of brown trout bag and possession limits in the upper Klamath and Trinity rivers, based on a petition that was submitted to the Commission that has support from several tribes and federal agencies.

Discussion

A stakeholder asked when the Department would release the size calculations, and Kevin answered that the calculations could be made available as soon as they are completed.

WRC Recommendation

WRC recommends that the Commission support the proposed regulation changes for mammal hunting, waterfowl hunting, Central Valley sport fishing, and Klamath River Basin sport fishing for the 2020-21 seasons, as recommended by the Department, and ask the Department to consider a two-week extension to the Central Valley salmon fishing season on the Sacramento River.

6. Simplification of statewide inland fishing regulations

Karen Mitchell presented on the history of the trout sportfishing simplification initiative and gave an update on its current status. A proposal will be presented and vetted at the January 2020 WRC meeting. The Department requested that WRC consider holding a special meeting in March to discuss the recommended regulations for each area in detail, to inform a potential WRC recommendation to FGC.

Kevin Shaffer explained that the impetus for regulation simplification came from the angling community. The Department sees this as an important component of its R3 initiatives. Many people seemed fine with simplification as a concept but did not want regulations changed that would affect them personally. Conversely, many public proposals and petitions would result in further complicating the regulations. It is the Department's task to "merge those two worlds," which is the main reason for the timeline delays experienced so far.

Discussion

A representative for NCGASA asked about the timing of the disposition of a regulation change petition (Petition #2018-014), regarding inland boat limits for finfish. Ari Cornman explained that the petition was denied by FGC but that, at the time of its denial, the Department committed to considering boat limits during the next regular sportfishing rulemaking package. Kevin observed that the simplification rulemaking was initially proposed to be completed in one year, but the longer timeline is also postponing the regular sportfishing package. Kevin stated that the Department's Fisheries Branch is devoting most of its resources to the simplification rulemaking, but he would speak with NCGASA to see if a solution could be identified.

WRC Recommendation

WRC recommends that the Commission schedule a special WRC meeting in March 2020, with a date to be determined, focused on the simplification of statewide inland fishing regulations proposal.

7. Bullfrogs and non-native turtles

Ari Cornman provided an update on the bullfrog and non-native turtle stakeholder engagement process. Staff is scheduling the next meeting of the agency team. The environmental/animal welfare team has met three times and made substantial progress. The industry team is still being formed. Legislative committees and caucuses will be engaged once all three teams have met.

No action was taken.

8. Future agenda items

(A) *Review work plan agenda topics and timeline*

Work plan topics identified for the next WRC meeting include:

- Initial vetting and discussion of the simplification of statewide inland fishing regulations
- Update on the bullfrog and non-native turtle stakeholder engagement project

(B) ***Potential new agenda topics for Commission consideration***

No new topics were identified to add to the current work plan.

Adjourn

The Committee adjourned at 10:42 a.m.

Wildlife Resources Committee (WRC) 2019-20 Work Plan
Scheduled Topics and Timeline for
Items Referred to WRC by the California Fish and Game Commission
Updated September 30, 2019

Topic	Category	2019 MAY Sacramento	2019 SEP Santa Rosa	2020 JAN Los Angeles Area
Annual Regulations				
Upland (Resident) Game Birds	Annual		X	
Sport Fishing	Annual			
Mammal Hunting	Annual	X	X/R	
Waterfowl	Annual	X	X/R	
Central Valley Salmon Sport Fishing	Annual	X	X/R	
Klamath River Basin Sport Fishing	Annual	X	X/R	
Regulations & Legislative Mandates				
Falconry	Referral for Review			
Department Lands Regulations	Regulatory	X/R		
Simplification of Statewide Inland Fishing Regulations	Regulatory	X	X	X
Special Projects				
American Bullfrog and Non-native Turtle Stakeholder Engagement Project	Referral for Review	X	X	X
Policies				
Delta Fisheries Forum Recommendations and Delta Fisheries Policy	Referral for Review	X/R		
Legislation				
365-Day Fishing Licenses (AB 1387)	Referral for Review	X/R		

KEY: X Discussion scheduled X/R Recommendation developed and moved to FGC

State of California
Department of Fish and Wildlife

RECEIVED
FISH & GAME COMMISSION

2019 JUL 11 AM 7:30

M e m o r a n d u m

Date: July 5, 2019

To: Melissa Miller-Henson
Acting Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Agenda Item for August 7-8, 2019, Fish and Game Commission Meeting: Request for Notice Authorization Re: Amend Section 473, Possession of Nongame Animals: Nutria**

The Department of Fish and Wildlife (Department) requests that the Fish and Game Commission (Commission) authorize publication of notice of its intent to consider an amendment to Section 473 banning the possession of live nutria, a non-native invasive rodent.

Authorization of this request to publish notice will allow for discussion October 9, and possible adoption at the December 11, 2019 Commission meeting.

Categorical Exemptions to Protect Natural Resources and the Environment

This memorandum describes staff's analysis of the use of a categorical exemption under the California Environmental Quality Act (CEQA).

The Commission's adoption of the proposed regulations is an action subject to CEQA. The review by Department staff pursuant to CEQA Guidelines leads staff to conclude that adoption of the regulations would properly fall within the Class 7 and Class 8 categorical exemptions (CEQA Guidelines Sections 15307, 15308). These two exemptions are related to agency actions authorized by statute to protect natural resources and the environment, and to maintain and enhance wildlife such as the current proposal.

No Exceptions to Categorical Exemptions Apply

As to the exceptions to categorical exemptions set forth in CEQA Guidelines Section 15300.2, including the prospect of unusual circumstances and related effects, staff has reviewed all the available information possessed by the Department relevant to the issue and does not believe the regulations pose any unusual circumstances that would constitute an exception to the categorical exemptions set forth above. The proposed activities are typical of those that fall within Class 7 and Class 8 generally. In addition, even if there were unusual circumstances, no potentially significant effects on either a project-specific or a cumulative basis are expected.

If you have any questions or need additional information, please contact Valerie Cook, Nutria Eradication Incident Commander, by telephone at 916-654-4267 or by email at Valerie.Cook@wildlife.ca.gov.

Attachments

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STATE OF CALIFORNIA
FISH AND GAME COMMISSION
INITIAL STATEMENT OF REASONS FOR REGULATORY ACTION

Amend Section 473
Title 14, California Code of Regulations
Re: Possession of Nongame Animals: Nutria

I. Date of Initial Statement of Reasons: June 11, 2019

II. Dates and Locations of Scheduled Hearings

(a) Notice Hearing: Date: August 7, 2019
Location: Sacramento

(b) Discussion Hearing: Date: October 9, 2019
Location: Valley Center

(c) Adoption Hearing: Date: December 11, 2019
Location: Sacramento

III. Description of Regulatory Action

(a) Statement of Specific Purpose of Regulation Change and Factual Basis for Determining that Regulation Change is Reasonably Necessary:

This amendment of Section 473 would protect the State's wildlife, wetland habitats, waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture from the detrimental impacts caused by invasive nutria (*Myocastor coypus*) by banning the possession of live nutria and thereby preventing new introductions of nutria in the state. The Department of Fish and Wildlife ("Department") has implemented a multi-million dollar nutria eradication program, and this regulation is an important part of this effort.

Current Regulation

Section 671, Importation, Transportation and Possession of Live Restricted Animals, restricts the possession of many non-native species. Nutria are a mammal of the order Rodentia; subsection 671(c)(2)(J) designates all rodents, including nutria, as a "detrimental animal." Nonetheless, possession of live nutria is authorized "under permit issued by the department," i.e., a "Restricted Species Permit."

Subsection 671.1, Permits for Restricted Species, describes the types of Restricted Species Permits issued by the Department and the qualifications needed to obtain a Restricted Species Permit. In addition, subsection 671.1(c)(5) sets forth the criteria for denying a new Restricted Species Permit application and the amendment of an existing permit. The criteria include failure to comply with the terms and conditions of the permit; failure to comply with state, federal, or municipal statutes or regulations; or, if the Department finds that application documents do not support the statement of use of the requested restricted species. But these denial criteria do not authorize the Department to deny an application solely because the applicant would like to possess a live nutria.

Section 650 authorizes the Department to issue permits to take or possess wildlife for scientific, educational, and/or propagation purposes ("Scientific Collecting Permits"). Like Section 671, Section 650 also provides for the legal possession of live nongame mammals, including nutria. Subsection 650(r), which addresses Permit Denial, sets forth criteria for denial of a new Scientific Collecting Permit application and the amendment of an existing permit. As with Restricted Species Permits, the Department does not have the authority to deny a request from a Scientific Collecting Permit applicant solely because the applicant would like to possess live nutria.

Section 679, Possession of Wildlife and Wildlife Rehabilitation, also provides for the legal possession of live nongame mammals, including nutria, by wildlife rehabilitation facilities authorized under a Department-issued permit to rehabilitate injured, diseased, or orphaned animals. Subsection 679(e)(2)(E) specifies that the Department may deny a permit if either an applicant fails to allow an inspection, the facility does not meet standards set forth in the Minimum Standards for Wildlife Rehabilitation, 2000, Third Edition, or if the applicant fails to meet all applicable standards specified in subsections 679(e)(2)(A)-(D). If the applicant is in good standing and qualified to handle and treat injured or diseased nutria, the Department does not have the authority to deny the request.

Section 473, Possession of Nongame Animals, states "Any nongame bird or mammal that has been legally taken pursuant to this chapter may be possessed." This regulation does not prohibit the possession of nutria pursuant to a Department-issued permit.

Proposed Regulation

The amendment of Section 473 makes it clear that the possession of a live nutria, including a live nutria possessed pursuant to a Department-issued permit, is unlawful. This amendment states:

> "(b) It is unlawful to possess live nutria (*Myocastor coypus*), and the Department shall not issue any permit authorizing possession of any live nutria."

Thus, the proposed amendment to Section 473 would make any possession of live nutria unlawful and authorize the Department to deny any application for the possession of live nutria.

Background

Nutria are semi-aquatic rodents native to South America and are one of the world's most destructive invasive species. Nutria are notorious for the extensive damage their herbivory and burrowing cause to wetlands, water conveyance infrastructure, and agriculture. Nutria were initially introduced to North America for the fur trade in the early 1900s and farmed in California in the 1930s-40s. Following the collapse of the market, nutria were released into the environment and established feral populations. Nutria were subsequently eradicated from the state in the 1970s.

In March 2017, a pregnant nutria was discovered in a managed wetland in California's San Joaquin Valley. Recognizing the extensive impacts nutria will undoubtedly cause to California's wetlands and wildlife, water conveyance and flood protection infrastructure, and California's agriculture, the Department responded by instituting an Incident Command System ("ICS") and redirecting staff and resources to implement long-term planning and eradication efforts. Since that time over 525 nutria have been taken, with additional detections confirmed, across San Joaquin, Stanislaus, Merced, Fresno, Mariposa, and Tuolumne Counties. The State's response now includes the Department of Food and Agriculture, U.S. Department of Agriculture, Department of Water Resources, and U.S. Fish and Wildlife Service. This effort has already cost the State millions of dollars to respond to this introduction and resulting infestation. In FY 19-20, the Department is slated to receive an on-going budget from the Legislature to address the problem, an $8.5 million grant from the Sacramento-San Joaquin Delta Conservancy, and will transition from the ICS to a dedicated, long-term Nutria Eradication Program; we anticipate the successful eradication of nutria from California, in total, will cost the State tens of millions of dollars.

Other State's Efforts at Eradication of Nutria

Resulting from broader introductions for the fur trade, nutria are now established in nearly 20 states, with most notable feral populations in Louisiana and the Chesapeake Bay. While both regions documented environmental damages in the 1950s, by the 1990s Louisiana had documented damage to and/or complete loss of over 100,000 coastal wetland acres and the Chesapeake Bay documented loss of over 50% of the marsh habitat within the Blackwater National Wildlife Refuge. Oregon and Washington have very high relative densities of nutria and have experienced extensive damage from nutria burrowing into levees, canals, and waterways.

The Chesapeake Bay Nutria Eradication Program was established in 2002, has now spent over $17 million to remove approximately 14,000 nutria from the Peninsula, and anticipates declaring successful eradication within the next few years. In contrast, the nutria population in Louisiana has been estimated in the millions and beyond eradication. Since 2002, Louisiana has paid up to $2.0 million per year in $5/tail bounties for harvest of up to 400,000 nutria every year in an effort to contain the population and reduce environmental damage. The populations in the Pacific Northwest are also beyond eradication, and the states have not been able to secure adequate funding for control.

(b) Goals and Benefits of the Regulation:

The goal of this regulation change is to prevent the possession of live nutria in California. This regulation will benefit the Department, the State, and its resources, by reducing the potential for future, additional introductions via released or escaped nutria. Ultimately, this regulation protects California's wetlands, waterways, infrastructure, water supplies, human health and safety, and agriculture.

(c) Authority and Reference Sections from Fish and Game Code for Regulation:

Authority: Section 4150, Fish and Game Code.
Reference: Sections 2118, 3005.5, and 4150, Fish and Game Code.

(d) Specific Technology or Equipment Required by Regulatory Change: None.

(e) Identification of Reports or Documents Supporting Regulation Change:

"Discovery of Invasive Nutria in California" (Attachment A)
"Nutria Eradication Program Update" (Attachment B)

(f) Public Discussions of Proposed Regulations Prior to Notice Publication:

Implementation of the eradication effort is ongoing and has been supported by individuals and environmental and agricultural groups interested in the protection of the environment and infrastructure from damage by nutria. To date, the following meetings regarding nutria have been held:

3/12/2018	CDFW outreach meeting to Ag Commissioners, trappers - San Luis NWR
3/12/2018	CDFW outreach meeting to Water Agencies, Land Managers - San Luis NWR
3/28/2018	Delta Conservancy Board Meeting
4/11/2018	Senate Ag Informational Committee Meeting
4/11/2018	Wildlands IPM Symposium
5/17/2018	Delta Protection Commission Meeting
5/19/2018	Grasslands Water District Public Meeting
5/22/2018	California Ag Commissioners and Sealers Association Spring Meeting
5/24/2018	Wildlife Conservation Board
6/13/2018	MARAC (Mutual Aid Region Information Exchange Meeting
6/13/2018	San Joaquin Farm Bureau Board Meeting
6/22/2018	Central Valley Flood Protection Board
7/11/2018	San Joaquin Farm Bureau Federation Workshop/Coalition for a Sustainable Delta
7/16/2018	WAFWA AIS Committee

7/18/2018	MARAC meeting - Region IV (Modesto)
7/25/2018	MARIX Meeting - Region V (Fresno)
7/27/2018	Department of Water Resources field staff
8/6/2018	Stanislaus County Ag Advisory Board Meeting
8/16/2018	CA Invasive Species Council Meeting
8/21/2018	San Joaquin County Board of Supervisors Meeting
8/22/2018	State Parks' Division of Boating and Waterways field staff
8/23/2018	Rotary Club of Newman
9/5/2018	Collaborative Science and Adaptive Management Program - Policy Group Meeting
9/11/2018	Bay-Delta Science Conference
10/23/2018	San Joaquin Farm Bureau Water Committee
11/5/2018	Delta Stewardship Council - Delta Interagency Implementation Committee (DPIIC)
11/6/2018	Delta Rec District Winter Weather Briefing (CalOES hosted)
11/8/2018	Alameda County grower CE training
11/8/2018	California Invasive Plant Council
11/14/2018	SSJ Delta Conservancy Board Meeting
11/14/2018	CA Forest Pest Council Meeting
11/29/2018	Association of Applied IPM Ecologists Conference (Visalia)
12/6/2018	Delta Independent Science Board non-native species workshop
2/7/2019	Western Section of the Wildlife Society Annual Meeting
3/19/2019	Wildlands IPM Symposium
4/4/2018	Yolo Basin Foundation Flyway Nights
4/8/2019	Delta Plan Interagency Implementation Committee
4/12/2019	Mokelumne River Association
4/30/2019	Assembly Committee on Water, Parks, and Wildlife Hearing on AJR-8
5/18/2019	Grasslands Water District Public Meeting
5/21/2019	California Association of Ag Commissioners and Sealers Association Spring Meeting
5/24/2019	Central Valley Flood Protection Board
6/5/2019	California Invasive Species Action Week - Lunchtime Webinar Series

IV. Description of Reasonable Alternatives to Regulatory Action

(a) Alternatives to Regulation Change: No alternative was considered.

(b) No Change Alternative:

If no regulatory change occurs, live nutria could be lawfully possessed by holders of restricted species, wildlife, rehabilitation, and scientific collecting permits. Possession of these animals would increase the risk of accidental or intentional reintroduction of nutria, frustrating Department efforts to eradicate this non-native invasive species and reverse the severe environmental impacts it causes.

(c) Consideration of Alternatives:

In view of information currently possessed, no reasonable alternative considered would be more effective in carrying out the purpose for which the regulation is proposed, would be as effective and less burdensome to affected private persons than the proposed regulation, or would be more cost-effective to affected private persons and equally effective in implementing the statutory policy or other provision of law.

V. Mitigation Measures Required by Regulatory Action: None.

VI. Impact of Regulatory Action

The potential for significant statewide adverse economic impacts that might result from the proposed regulatory action has been assessed, and the following initial determinations relative to the required statutory categories have been made:

(a) Significant Statewide Adverse Economic Impact Directly Affecting Businesses, Including the Ability of California Businesses to Compete with Businesses in Other States:

The proposed action will not have a significant statewide adverse economic impact directly affecting business, including the ability of California businesses to compete with businesses in other states. The proposed action is an additional component of the state’s nutria eradication program that is anticipated to minimize the costly risks to infrastructure and resources that nutria pose. Reducing the potential for the spread of escaped nutria should help protect California’s business activities that draw upon well-functioning wetlands, waterways, infrastructure, and water supplies, such as agriculture and associated businesses.

(b) Impact on the Creation or Elimination of Jobs Within the State, the Creation of New Businesses or the Elimination of Existing Businesses, or the Expansion of Businesses in California; Benefits of the Regulation to the Health and Welfare of California Residents, Worker Safety, and the State’s Environment:

The Commission anticipates no impacts on the creation or elimination of jobs within the state and no impact on the creation of new businesses or the elimination of existing businesses because the proposed amendment is anticipated to aid in the preservation of existing water infrastructure with no cost to current business activities. The Commission anticipates benefits to the health and welfare of California residents by the protection of water supplies. The proposed action is not anticipated to directly affect worker safety. The Commission anticipates benefits to the State’s environment by supporting strategies that further the control of invasive species.

(c) Cost Impacts on a Representative Private Person or Business:

The agency is not aware of any cost impacts that a representative private person or business would necessarily incur in reasonable compliance with the proposed action.

(d) Costs or Savings to State Agencies or Costs/Savings in Federal Funding to the State:

No new costs to the State. Additionally, the proposed action will aid in the prevention of future importations and releases, preventing loss of state agency and/or federal funding to response costs.

(e) Nondiscretionary Costs/Savings to Local Agencies: None.

(f) Programs Mandated on Local Agencies or School Districts: None.

(g) Costs Imposed on Any Local Agency or School District that is Required to be Reimbursed Under Part 7 (commencing with Section 17500) of Division 4, Government Code: None.

(h) Effect on Housing Costs: None.

VII. Economic Impact Assessment

(a) Effects of the Regulation on the Creation or Elimination of Jobs Within the State:

The Commission anticipates no impacts on the creation or elimination of jobs within the state because the proposed action would have such limited scope to affect businesses or the demand for labor.

(b) Effects of the Regulation on the Creation of New Businesses or the Elimination of Existing Businesses Within the State:

The Commission does not anticipate any effects of the proposed regulation on the creation of new businesses or the elimination of existing businesses within the state because it would not directly affect the demand for business products or services.

(c) Effects of the Regulation on the Expansion of Businesses Currently Doing Business Within the State:

The Commission does not anticipate the any effects of the proposed regulation on the expansion of businesses currently doing business within the state because the proposed action would not directly affect the demand for business products or services.

(d) Benefits of the Regulation to the Health and Welfare of California Residents:

The Commission anticipates benefits to the health and welfare of California residents by contributing toward the protection of water supplies.

(e) Benefits of the Regulation to Worker Safety:

The Commission does not anticipate benefits to worker safety because the proposed amendment would not impact working conditions.

(f) Benefits of the Regulation to the State's Environment:

The Commission anticipates benefits to the State’s environment through support of strategies that control damaging invasive species.

(g) Other Benefits of the Regulation: None.

Informative Digest/Policy Statement Overview

This amendment of Section 473 would ban the possession of live nutria to prevent new introductions of nutria in the state. Nutria affect the State's wildlife by damaging wetland habitats, and put waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture at risk from damage through their burrowing and herbivory of aquatic vegetation. The Department has implemented a multi-million dollar nutria eradication program, and this regulation is an integral part of this effort.

Possession of nutria is only possible under a permit issued by the Department. But, the permit denial provisions in California Code of Regulations, Title 14, subsection 671.1(c)(5), sections 670 and 650 have no provisions for banning the possession of live nutria in California.

Section 473 provides exceptions to FGC 4150, allowing for the possession of legally taken non-game birds and mammals, including rodents such as nutria, but not prohibiting the possession of live nutria pursuant to a Department-issued permit. Thus, the Commission proposes an addition to subsection 473(b) stating:

> "It is unlawful to possess live nutria (*Myocastor coypus*), and the Department shall not issue any permit authorizing possession of any live nutria."

Goals and Benefits of the Regulation:

The goal of this regulation change is to prohibit any possession of live nutria and ensure the Department no longer issues permits allowing the possession of live nutria in California. This regulation will benefit the Department, State, and its resources by reducing the potential for future, additional introductions via released or escaped nutria and thereby protect California's wildlife, wetland habitats, waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture.

Proposed Regulatory Language

Section 473, Title 14, CCR, is amended to read:

§ 473. Possession of Nongame Animals.

(a) Any nongame bird or mammal that has been legally taken pursuant to this chapter may be possessed.

(b) It is unlawful to possess live nutria *(Myocastor coypus)*, and the Department shall not issue any permit authorizing possession of any live nutria.

Note: Authority cited: Section 4150, Fish and Game Code. Reference: ~~Section~~ Sections 2118, 3005.5, and 4150, Fish and Game Code.

Discovery of invasive nutria in California

Landowners, we need your help...

CDFW has deployed nutria survey teams from the Delta through the San Joaquin Valley and needs written access permissions to enter or cross private properties for the purposes of conducting nutria surveys and, where detected, implementing trapping efforts. Landowners and tenants, we need your help; so CDFW can survey for and remove destructive nutria from your properties, complete and submit the Nutria Project Temporary Entry Permit.

How to Report a Sighting

Suspected observations or potential signs of nutria should be **photographed** and immediately reported to CDFW's Invasive Species Program online, by e-mail to invasives@wildlife.ca.gov, or by phone at (866) 440-9530. Observations on state or federal lands should be immediately reported to local agency staff on the property. Reports will be followed up on by the interagency nutria response team and will help in their eradication effort. If possible, photos of animals should include views of the whiskers, front or hind foot, or tail; for optimal photos of tracks, include an object for size reference (e.g., pencil, quarter, wallet) and take the photo from the side, at an angle (≤ 45º) to cast shadows into the track.

Please consult the nutria identification flyer (PDF) or "Nutria Identification" section below for reference images and other commonly confused species. Additionally, the Delta Stewardship Council has developed a convenient nutria pocket guide to aid in field identification of nutria; to request the printed pocket guide(s), please contact CDFW at Invasives@wildlife.ca.gov or (866) 440-9530.

General Information

For general information on nutria biology and ecology please see the nutria species profile page.

Large, male nutria trapped in a private wetland in Merced County, June 2017. CDFA photo.

Nutria Impacts

Through their extensive herbivory and burrowing habits, nutria have devastating impacts on wetland habitats, agriculture, and water conveyance/flood protection infrastructure. Nutria consume up to 25% of their body weight in above- and below-ground plant material each day. Due to their feeding habits, up to 10 times the amount of plant material consumed is destroyed, causing extensive damage to the native plant community, soil structure, and nearby agricultural crops. The loss of plant cover and soil organic matter results in severe erosion of soils, in some cases converting marsh to open water. Further, nutria burrow into banks and levees, creating complex dens that span as far as 6 meters deep and 50 meters into the bank and often cause severe streambank erosion, increased sedimentation, levee failures, and roadbed collapses.

Wetland loss caused by nutria damage in Blackwater National Wildlife Refuge, Delmarva Peninsula, Chesapeake Bay. Left, normal marsh in 1939 before nutria introduction in the 1940s. Right, by 1989, over 50% of the Refuge's marshes had been converted to open water due to the destructive feeding habits of nutria. Photos courtesy of USFWS.

An exclosure experiment in a Louisiana marsh demonstrating the severe ecological damages caused by nutria herbivory in wetland habitats. Photo courtesy of Louisiana Dept. of Wildlife and Fisheries.

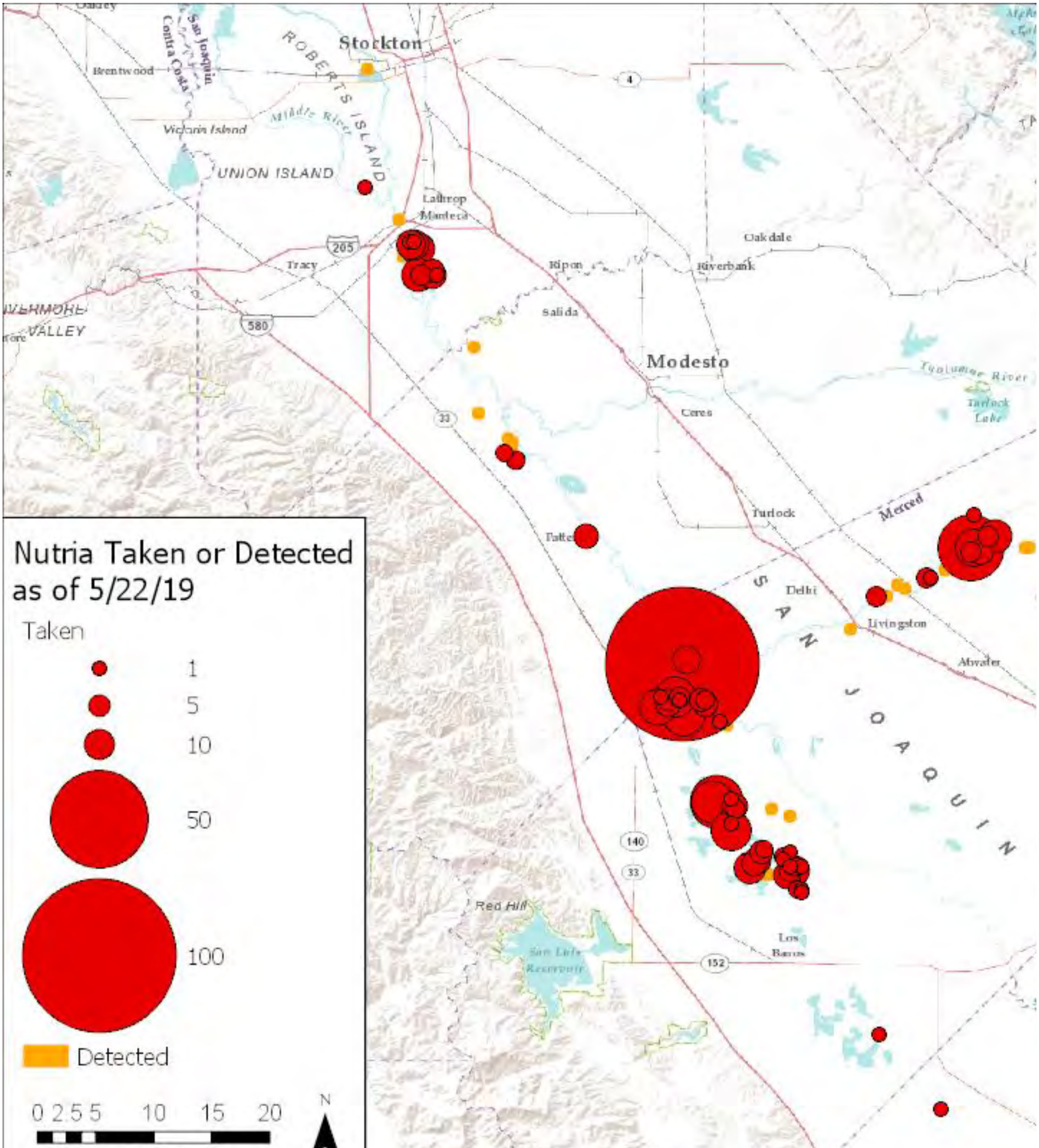
Nutria burrowing causes extensive damage to water infrastructure, banks, and levees, and creates a hazard for people, livestock, and machine operators. Potential levee and dike failures due to nutria burrowing have serious implications for flood protection, water delivery, and agricultural irrigation in California. Left, nutria burrow in Tualatin National Wildlife Refuge in Oregon. Photo courtesy of USFWS. Right, extensive burrowing damage by nutria in Oregon. Photo courtesy of Trevor Sheffels, PSU.

Discovery in California

Confirmed detections of nutria in California can be viewed in the nutria detection map (PDF). As of May 22, 2019, 510 nutria have been taken in California, with several additional animals confirmed present, across Merced, Stanislaus, San Joaquin, Fresno, Tuolumne, and Mariposa Counties. In September 2018, the first reproducing population of nutria within the legal Sacramento-San Joaquin Delta boundary was discovered south of Lathrop (San Joaquin County). In May 2019, a nutria was detected near Rough and Ready Island, approximately 16 miles north of the nearest known population and previous detections.

Nutria Taken in California, by County (as of 5/22/19)

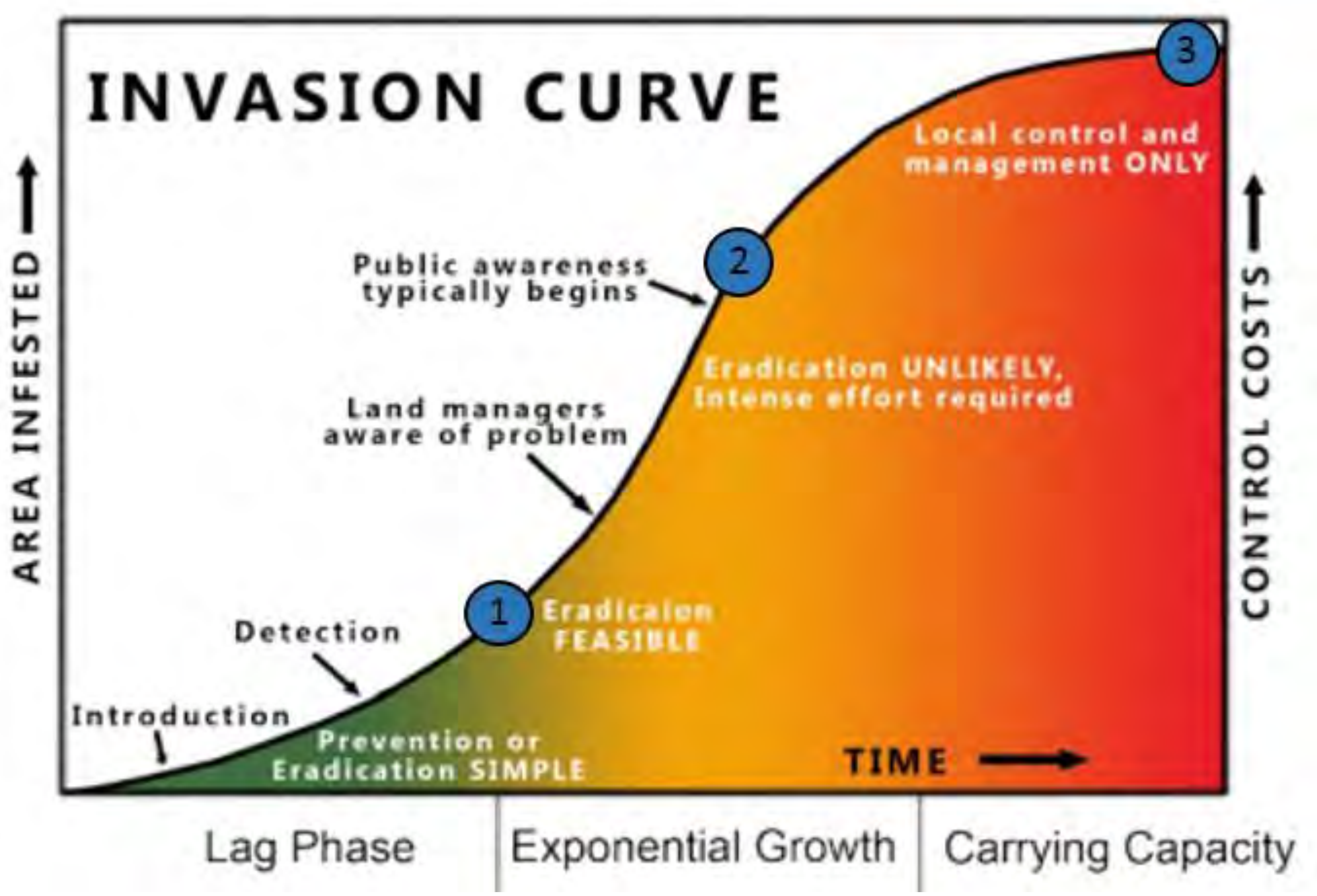
Total	Merced	San Joaquin	Stanislaus	Mariposa	Fresno
510	430	65	12	2	1



Nutria Taken or Detected as of 5/22/19
Taken
1
5
10
50
100
Detected
0 2.5 5 10 15 20
Miles
N
Stockton
Brentwood
ROBERTS ISLAND
Victoria Island
UNION ISLAND
Middle River
Lathrop
Manteca
Tracy
Ripon
Riverbank
Oakdale
Salida
Modesto
Tuolumne River
Turlock Lake
Ceres
Turlock
Merced
Delhi
Livingston
Atwater
SAN JOAQUIN
Red Hill
San Luis Reservoir
Los Banos
VALLEY

Eradication Effort

CDFW is collaborating with other agencies and local partners to develop the most effective strategy for eradicating nutria from California. As depicted in the "Invasion Curve" figure below, invasive species infestations typically experience a lag phase, while population size and area infested are relatively small, successful eradication is most feasible, and control efforts are most cost-efficient. As time progresses, the population size, area infested, and costs required for control increase exponentially, and the probability of successful eradication is lost. Conceptually, (1) represents where we believe the current extent of the nutria population is in California; eradication is feasible with rapid response; (2) represents the nutria population in the Chesapeake Bay (Delmarva Peninsula) prior to implementation of the Chesapeake Bay Nutria Eradication Project (CBNEP). The CBNEP strategically removed over 14,000 nutria from 2000-2015 and has not detected a nutria since early 2015. (3) represents the nutria population in Louisiana, where population control costs up to $2 million dollars each year for bounty harvests alone.



Currently, there is a small window of opportunity to successfully eradicate the population of nutria from California. As time progresses, the population size and geographic area of infestation are increasing, along with the effort, resources, and funds required for successful eradication. Over time, the probability of successful eradication decreases, and California would be left to manage and mitigate the devastating impacts of nutria on wetlands, agriculture, and water conveyance/flood control infrastructure.

The interagency Nutria Response Team includes representatives from CDFW, the California Departments of Food and Agriculture, Parks and Recreation, and Water Resources, the U.S. Department of Agriculture, the U.S. Fish and Wildlife Service and local county agricultural commissioner offices. The team is currently preparing an eradication plan, the first stage of which is determining the full extent of the infestation. Assistance from local landowners and the public throughout the Central Valley, Sacramento-San Joaquin Delta, and beyond is critical to successfully delineating the population.

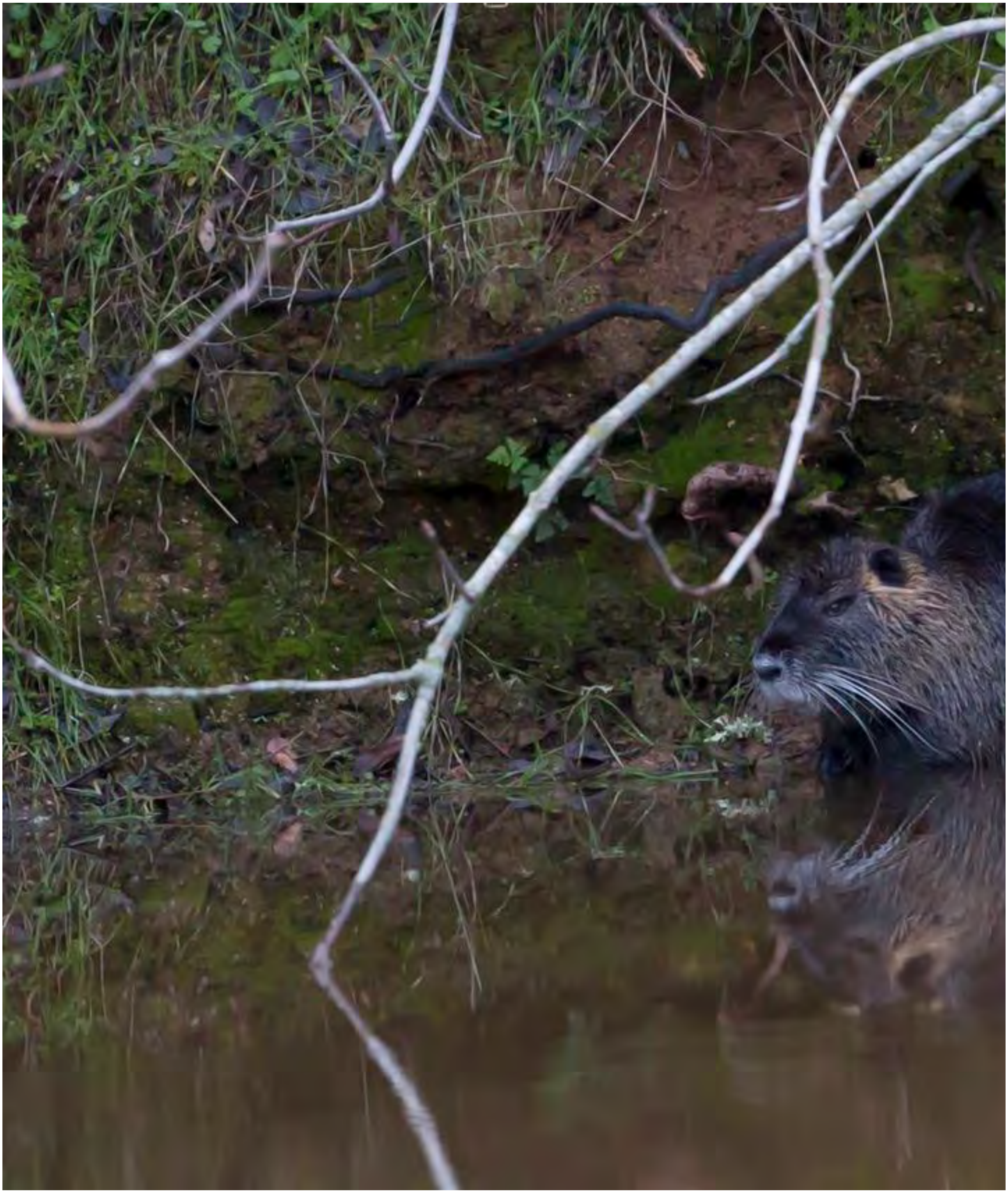
Take by Landowners/Hunters

CDFW has classified nutria as a nongame mammal. Fish and Game Code §4152 specifies property owners or their agents (who possess written permission from the owner or tenant) may take nutria at any time by any legal means to address damage to crops or property. Restrictions apply to the use of traps and types of traps. Nutria are a Restricted Species in California under the California Code of Regulations, Title 14, Section 671, and cannot be imported, transported, or possessed live in the state of California.

Given their very similar appearances, particularly in overlapping size classes, citizens should take extra precaution to distinguish nutria from other aquatic mammals (PDF); the majority of nutria reports received by CDFW have been muskrats, as have been some "nutria" featured in the media. Any nutria taken on private or public land should be reported to CDFW as soon as possible for purposes of delineating the extent of the infestation. At minimum, CDFW needs photos to confirm identification; preferably, CDFW needs the carcass to determine sex, age, and reproductive status.

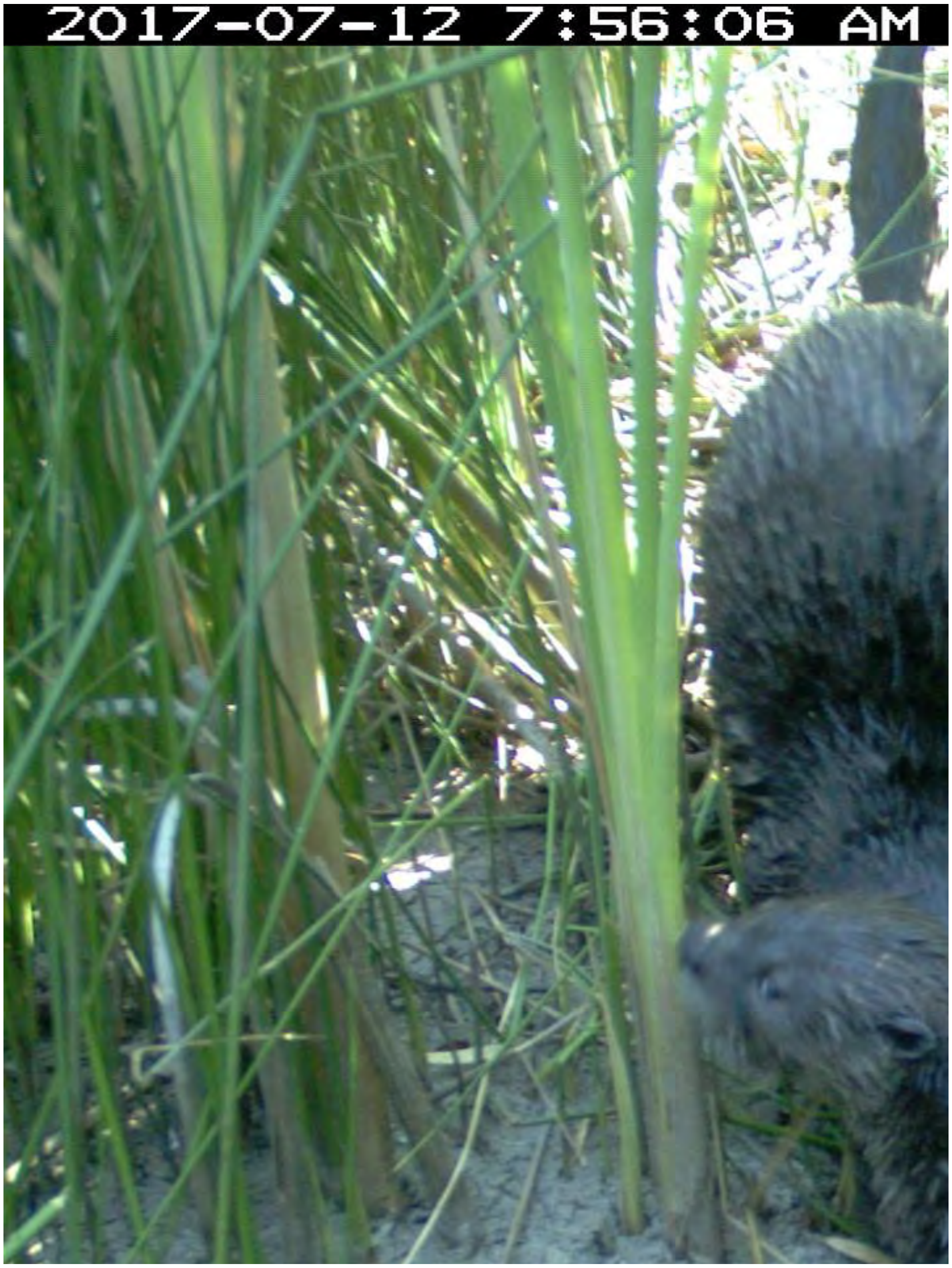
Nutria Identification

Nutria are large, semi-aquatic rodents that reach up to 2.5 feet in body length, 12- to 18-inch tail length and +20 pounds in weight. Nutria strongly resemble native beaver and muskrat, but are distinguished by their round, sparsely haired tails and white whiskers (see CDFW’s nutria ID guide (PDF) or Delta Stewardship Council's nutria pocket guide). Both nutria and muskrat often have white muzzles, but muskrats have dark whiskers, nearly triangular (laterally compressed) tails and reach a maximum size of five pounds. Beavers have wide, flattened tails and dark whiskers and reach up to 60 pounds. Other small mammals can sometimes be mistaken for nutria if seen briefly or in low light conditions, including river otters and mink.



Adult nutria discovered in a private pond in Tuolumne County, east of Don Pedro Reservoir. Though muskrats may have a white muzzle, both muskrats and beaver have dark whiskers. Nutria have characteristic white whiskers, and most often have conspicuous, darks ears with light-colored fur underneath, as seen in this image. Photo courtesy of Peggy Sells.

California has several aquatic mammals that occur in the same habitats and may be confused with nutria. Top left, muskrat, note the nearly triangular tail and dark whiskers that distinguish muskrats from small nutria, photo courtesy of Missouri Dept. of Conservation. Top right, American beaver, note the broad, flat tail that, along with dark whiskers, distinguishes small beavers from nutria, CDFW photo. Bottom, American mink, note the fully furred tail, dark whiskers, and weasel-like body form, photo courtesy of Alaska Dept. of Fish and Game.


2017-07-12 7:56:06 AM

Left, juvenile river otters, pictured here in a cattail marsh, may also be mistaken for nutria. Note the long body and thick, fully-furred tail, CDFW photo. Right adult river otter, photo courtesy of National Park Service.

Nutria often have a dark undercoat, with lighter-colored guard hairs. Their dark, conspicuous ears, with lighter fur underneath, are helpful in distinguishing nutria from other aquatic mammals when their round tail is not clearly visible. CDFW photos.

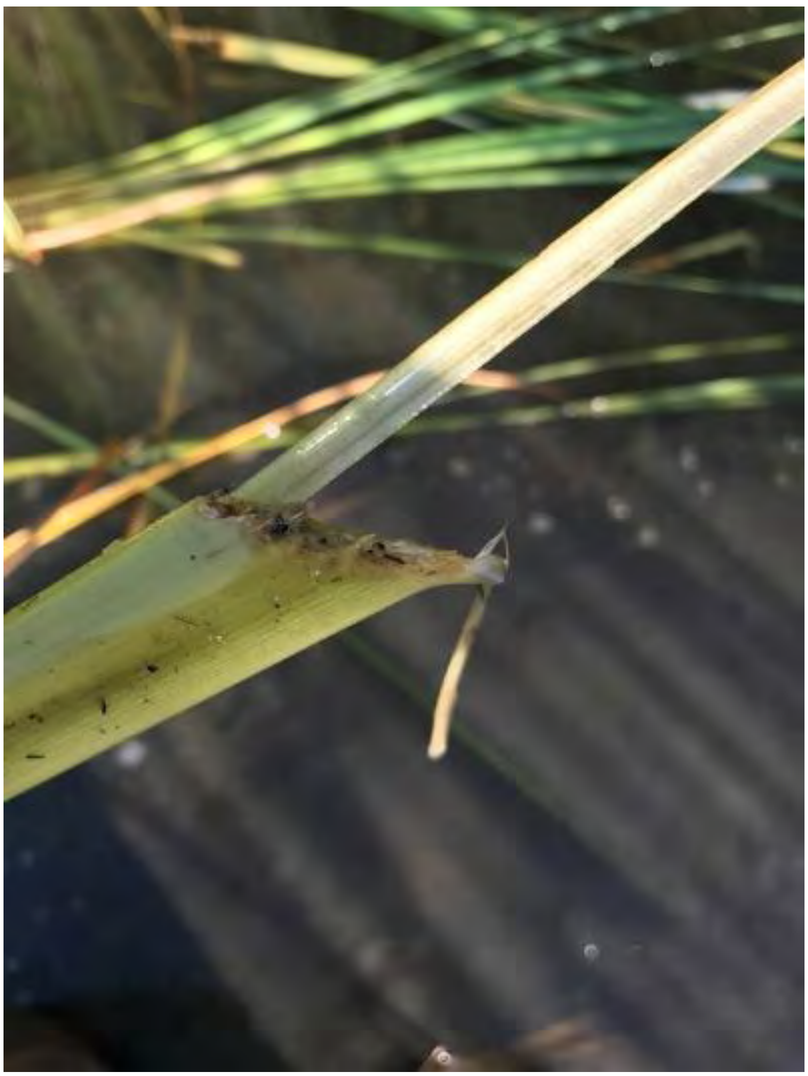
Left, nutria front foot, showing the four toes visible in tracks and the barely visible fifth, residual toe on the inner, lower area of the foot. Right, nutria hind foot, showing the webbing between the inner four toes and outer, fifth toe free from webbing. CDFW photos.

Habitat

Nutria can be found anywhere in or near freshwater or estuaries. Thus far, they have been found in cattail and tule marshes, ponds, canals, sloughs, and rivers. All currently known locations are upstream of the Sacramento-San Joaquin Delta, which provides a vast amount of ideal and interconnected habitat for nutria.

Look for nutria and signs of nutria presence in wetlands, canals, rivers, and creeks, along levees and riparian areas, in flooded agricultural fields adjacent to waterways, and in the transition zone between wetland and terrestrial habitat.

Because nutria are wasteful feeders, signs of presence typically include cut, emergent vegetation (e.g. cattails and bulrushes), with only the basal portions eaten and the cut stems left floating, or grazed tops of new growth. Nutria create runs between feeding sites and burrows. Nutria often pile cuttings to create feeding/grooming platforms. Nutria construct burrows with entrances typically below the water line, though changing water levels may reveal openings. Nutria tracks have four visible front toes and, on their hind feet, webbing between four of five toes. Tracks are often accompanied by narrow tail drags.&



Nutria cuttings have a 45 degree angle bite and often have a residual strip attached to the stem. CDFW photos.

Top left, nutria often pile their vegetation cuttings into feeding/grooming beds. Top right, cattails cut by nutria and left lying in the marsh, a characteristic sign of nutria presence. Bottom, a vegetation clearing or "eat out" with cuttings floating throughout the area, characteristic signs of nutria herbivory damage. CDFW photos.

Nutria create "runs" in the vegetation between feeding areas and near entry/exit points along the water's edge. CDFW photo.

Nutria scat is distinctly grooved and floats on the water's surface. CDFW photos.

Left, closeup of nutria tracks showing webbing between 4 of 5 toes on the hind foot. CDFW photo. Right, nutria tracks and tail drag. Photo courtesy of USDA.

Habitat Conservation Planning Branch
1700 9th Street, 2nd Floor, Sacramento, CA 95811
Mailing: P.O. Box 944209, Sacramento, CA 94244-2090
(916) 653-4875

CDFW Invasive Species Program
1416 Ninth Street, 12th Floor
Sacramento CA 95814

California Department of Fish and Wildlife
June 11, 2019

Nutria Eradication Program Update

Since implementing the Nutria Eradication Incident Command System in March 2018, the California Department of Fish and Wildlife's redirected field crews, along with three USDA-Wildlife Services trappers and the California Department of Food and Agriculture's delimitation crews, have:

- Completed full and/or rapid assessments on over 480K acres
- Set up 753 camera stations
  - Conducted over 2845 camera checks
- Confirmed nutria within 143 [40-acre] cells (Figure 1)
- Deployed 1269 trap sets for a total of 16018 trap nights
- Taken or accounted for the take of 525 nutria (since Mar 2017)
  - Merced- 438
  - San Joaquin- 69 (68 from Walthall Slough)
  - Stanislaus- 15
  - Mariposa- 2
  - Fresno- 1

- Of 521 necropsies:
  - 1.18 sex ratio (M:F)
  - Of the females captured:
    - 25% of juvenile (2-6 mos.) females have been pregnant
    - 59% of subadult (6-14 mos.) females have been pregnant
    - 75% of adult (>14 months of age) females have been pregnant
  - Along with the pregnant females, 626 fetal nutria have been removed from the population
  - Litter size ranged from 2-11, with an average of 6.1
    - Average litter size for adult females (> 14 mos.) is 6.8

With dedicated program funding anticipated through the Governor's FY 19-20 budget and grants from the Wildlife Conservation Board, U.S. Fish and Wildlife Service, and Sacramento-San Joaquin Delta Conservancy (SSJDC), including a new $8.5 M award from the SSJDC, the Department is currently building a dedicated team of 30-40 to eradicate nutria from California. The Department expects to transition from the ICS into the dedicated program during summer 2019.

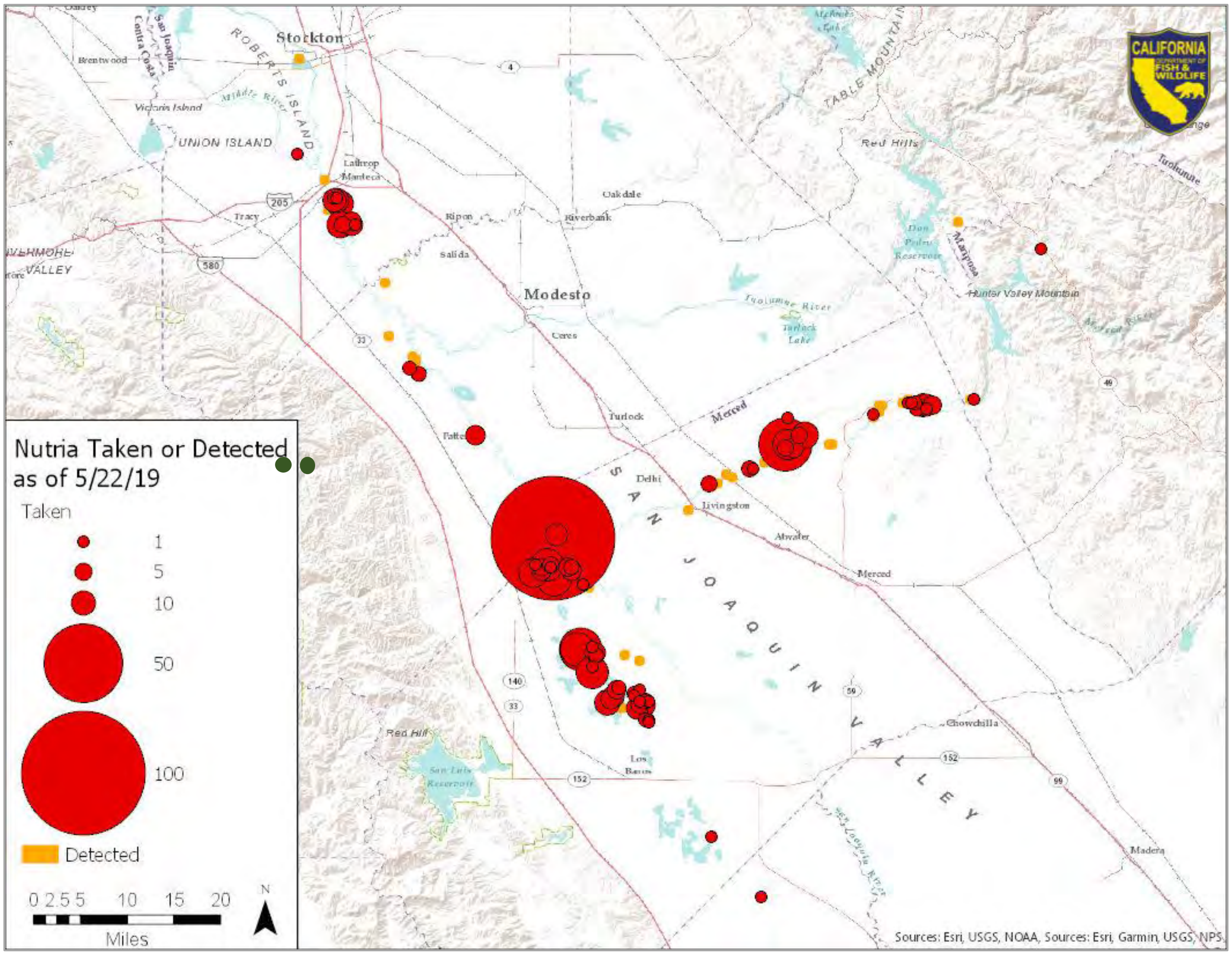


Figure 1. As of June 2019, 525 nutria have been taken or otherwise confirmed taken in California, with the following distribution of take by county: Merced – 438; San Joaquin – 69; Stanislaus – 15; Mariposa – 2; Fresno – 1; Tuolumne – 0; confirmed present. Map of take densities by 40-acre cell is as of 5/22/19.

Print Form

Notice of Exemption

Appendix E

To: Office of Planning and Research
P.O. Box 3044, Room 113
Sacramento, CA 95812-3044

County Clerk
County of: N/A

From: (Public Agency): Fish and Game Commission
PO Box 944209
Sacramento, CA 94244-2090
(Address)

Project Title: Amend Title 14, CCR, Section 473, Possession of Non-game Animals: Nutria.

Project Applicant: Fish and Game Commission

Project Location - Specific:

Statewide

Project Location - City: N/A Project Location - County: N/A

Description of Nature, Purpose and Beneficiaries of Project:

The amendment of Section 473 would ban the possession of live nutria (Myocastor coypus), to prevent new introductions of the destructive rodent to the state.

Name of Public Agency Approving Project: Fish and Game Commission

Name of Person or Agency Carrying Out Project: California Department of Fish and Wildlife

Exempt Status: **(check one):**

- ☐ Ministerial (Sec. 21080(b)(1); 15268);
- ☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
- ☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
- ☒ Categorical Exemption. State type and section number: §15307, 15308, Title 14, CCR
- ☐ Statutory Exemptions. State code number: ______

Reasons why project is exempt:
The proposed amendments do not have the possibility of impact on the environment because the changes are an effort to protect the State's wildlife, wetland habitats, waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture from the detrimental impacts caused by invasive nutria (Myocastor coypus),

Lead Agency
Contact Person: ______ Area Code/Telephone/Extension: 916-653-4899

If filed by applicant:

1. Attach certified document of exemption finding.
2. Has a Notice of Exemption been filed by the public agency approving the project?. ☐ Yes ☐ No

Signature: ______ Date: ______ Title: ______

☒ Signed by Lead Agency ☐ Signed by Applicant

Authority cited: Sections 21083 and 21110, Public Resources Code.
Reference: Sections 21108, 21152, and 21152.1, Public Resources Code.

Date Received for filing at OPR: ______

December 12, 2019

ATTACHMENT TO NOTICE OF EXEMPTION
Amendment of Section 473, Title 14, California Code of Regulations
Possession of Nongame Animals: Nutria

The California Fish and Game Commission (Commission) has taken final action under the Fish and Game Code and the Administrative Procedure Act (APA) with respect to the project discussed on December 11, 2019. In taking its final action for the purposes of the California Environmental Quality Act (CEQA, Pub. Resources Code, § 21000 *et seq.),* the Commission adopted the regulations relying on the CEQA exemption for projects where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment.

Regulations

In an effort to protect the State's wildlife, wetland habitats, waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture from the detrimental impacts caused by invasive nutria (*Myocastor coypus*), the amendment of Section 473 would ban the possession of live nutria to prevent new introductions of the destructive rodent to the state. The Department of Fish and Wildlife has implemented a multi-million dollar nutria eradication program and the regulation is an important part of this effort.

Categorical Exemptions to Protect Natural Resources and the Environment

The purpose of this explanation is to describe staff's analysis of use of the categorical exemptions under the California Environmental Quality Act (CEQA) as it relates to this regulatory action.

The Commission's adoption of the proposed regulations is an action subject to CEQA. The review by Department staff pursuant to CEQA Guidelines Section 15300, Title 14, CCR, leads staff to conclude that adoption of the regulations would properly fall within the Class 7 and Class 8 categorical exemptions (sections 15307, 15308). These two exemptions are related to agency actions authorized by statute to protect natural resources and the environment.

The proposed amendments do not have the possibility of impact on the environment because the changes are an effort to protect the State's wildlife, wetland habitats, waterways, water supplies, water conveyance and flood protection infrastructure, and agriculture from the detrimental impacts caused by invasive nutria (*Myocastor coypus*),

No Exceptions to Categorical Exemptions Apply

As to the exceptions to categorical exemptions set forth in CEQA Guidelines section 15300.2, including the prospect of unusual circumstances and related effects, staff has reviewed all of the available information possessed by the Department relevant to the issue and does not believe adoption of the regulations poses any unusual circumstances that would constitute an exception to the categorical exemptions set forth above.

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations:
SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT

DEPARTMENT NAME	CONTACT PERSON	EMAIL ADDRESS	TELEPHONE NUMBER
Fish and Game Commission	Margaret Duncan	margaret.duncan@wildlife.ca.gov	916 653-4674

DESCRIPTIVE TITLE FROM NOTICE REGISTER OR FORM 400	NOTICE FILE NUMBER
Amend Section 473 Title 14, CCR, Re: Possession of Nongame Animals: Nutria	Z

A. ESTIMATED PRIVATE SECTOR COST IMPACTS *Include calculations and assumptions in the rulemaking record.*

1. Check the appropriate box(es) below to indicate whether this regulation:

- ☐ a. Impacts business and/or employees
- ☐ b. Impacts small businesses
- ☐ c. Impacts jobs or occupations
- ☐ d. Impacts California competitiveness
- ☐ e. Imposes reporting requirements
- ☐ f. Imposes prescriptive instead of performance
- ☐ g. Impacts individuals
- ☒ h. None of the above (Explain below):

Presently there are no businesses or persons to be impacted by this regulation

If any box in Items 1 a through g is checked, complete this Economic Impact Statement.
If box in Item 1.h. is checked, complete the Fiscal Impact Statement as appropriate.

2. The ______________________ (Agency/Department) estimates that the economic impact of this regulation (which includes the fiscal impact) is:

- ☐ Below $10 million
- ☐ Between $10 and $25 million
- ☐ Between $25 and $50 million
- ☐ Over $50 million *[If the economic impact is over $50 million, agencies are required to submit a Standardized Regulatory Impact Assessment as specified in Government Code Section 11346.3(c)]*

3. Enter the total number of businesses impacted: ______________

Describe the types of businesses (Include nonprofits): ______________

Enter the number or percentage of total businesses impacted that are small businesses: ______________

4. Enter the number of businesses that will be created: ______________ eliminated: ______________

Explain: ______________

5. Indicate the geographic extent of impacts: ☐ Statewide

☐ Local or regional (List areas): ______________

6. Enter the number of jobs created: ______________ and eliminated: ______________

Describe the types of jobs or occupations impacted: ______________

7. Will the regulation affect the ability of California businesses to compete with other states by making it more costly to produce goods or services here? ☐ YES ☐ NO

If YES, explain briefly: ______________

Instructions and Code Citations:
SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT (CONTINUED)

B. ESTIMATED COSTS *Include calculations and assumptions in the rulemaking record.*

1. What are the total statewide dollar costs that businesses and individuals may incur to comply with this regulation over its lifetime? $ ______

   a. Initial costs for a small business: $ ______ Annual ongoing costs: $ ______ Years: ______

   b. Initial costs for a typical business: $ ______ Annual ongoing costs: $ ______ Years: ______

   c. Initial costs for an individual: $ ______ Annual ongoing costs: $ ______ Years: ______

   d. Describe other economic costs that may occur: ______

2. If multiple industries are impacted, enter the share of total costs for each industry: ______

3. If the regulation imposes reporting requirements, enter the annual costs a typical business may incur to comply with these requirements. *Include the dollar costs to do programming, record keeping, reporting, and other paperwork, whether or not the paperwork must be submitted.* $ ______

4. Will this regulation directly impact housing costs? ☐ YES ☐ NO

   If YES, enter the annual dollar cost per housing unit: $ ______

   Number of units: ______

5. Are there comparable Federal regulations? ☐ YES ☐ NO

   Explain the need for State regulation given the existence or absence of Federal regulations: ______

   Enter any additional costs to businesses and/or individuals that may be due to State - Federal differences: $ ______

C. ESTIMATED BENEFITS *Estimation of the dollar value of benefits is not specifically required by rulemaking law, but encouraged.*

1. Briefly summarize the benefits of the regulation, which may include among others, the health and welfare of California residents, worker safety and the State's environment: ______

2. Are the benefits the result of: ☐ specific statutory requirements, or ☐ goals developed by the agency based on broad statutory authority?

   Explain: ______

3. What are the total statewide benefits from this regulation over its lifetime? $ ______

4. Briefly describe any expansion of businesses currently doing business within the State of California that would result from this regulation: ______

D. ALTERNATIVES TO THE REGULATION *Include calculations and assumptions in the rulemaking record. Estimation of the dollar value of benefits is not specifically required by rulemaking law, but encouraged.*

1. List alternatives considered and describe them below. If no alternatives were considered, explain why not: No other alternative were considered.

   The proposed action was found to be the most effective and least burdensome to affected private persons and businesses.

Instructions and Code Citations:
SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT (CONTINUED)

2. Summarize the total statewide costs and benefits from this regulation and each alternative considered:

Regulation: Benefit: $ ______________ Cost: $ ______________

Alternative 1: Benefit: $ ______________ Cost: $ ______________

Alternative 2: Benefit: $ ______________ Cost: $ ______________

3. Briefly discuss any quantification issues that are relevant to a comparison of estimated costs and benefits for this regulation or alternatives: ______________

4. Rulemaking law requires agencies to consider performance standards as an alternative, if a regulation mandates the use of specific technologies or equipment, or prescribes specific actions or procedures. Were performance standards considered to lower compliance costs? ☐ YES ☐ NO

Explain: ______________

E. MAJOR REGULATIONS *Include calculations and assumptions in the rulemaking record.*

California Environmental Protection Agency (Cal/EPA) boards, offices and departments are required to submit the following (per Health and Safety Code section 57005). Otherwise, skip to E4.

1. Will the estimated costs of this regulation to California business enterprises **exceed $10 million**? ☐ YES ☐ NO

If YES, complete E2. and E3
If NO, skip to E4

2. Briefly describe each alternative, or combination of alternatives, for which a cost-effectiveness analysis was performed:

Alternative 1: ______________

Alternative 2: ______________

(Attach additional pages for other alternatives)

3. For the regulation, and each alternative just described, enter the estimated total cost and overall cost-effectiveness ratio:

Regulation: Total Cost $ ______________ Cost-effectiveness ratio: $ ______________

Alternative 1: Total Cost $ ______________ Cost-effectiveness ratio: $ ______________

Alternative 2: Total Cost $ ______________ Cost-effectiveness ratio: $ ______________

4. Will the regulation subject to OAL review have an estimated economic impact to business enterprises and individuals located in or doing business in California exceeding $50 million in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through12 months after the major regulation is estimated to be fully implemented?

☐ YES ☐ NO

If YES, agencies are required to submit a Standardized Regulatory Impact Assessment (SRIA) as specified in Government Code Section 11346.3(c) and to include the SRIA in the Initial Statement of Reasons.

5. Briefly describe the following:

The increase or decrease of investment in the State: ______________

The incentive for innovation in products, materials or processes: ______________

The benefits of the regulations, including, but not limited to, benefits to the health, safety, and welfare of California residents, worker safety, and the state's environment and quality of life, among any other benefits identified by the agency: ______________

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations: SAM Section 6601-6616

FISCAL IMPACT STATEMENT

A. FISCAL EFFECT ON LOCAL GOVERNMENT *Indicate appropriate boxes 1 through 6 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year which are reimbursable by the State. (Approximate) (Pursuant to Section 6 of Article XIII B of the California Constitution and Sections 17500 et seq. of the Government Code).

$ ________

☐ a. Funding provided in ________

Budget Act of ________ or Chapter ________ , Statutes of ________

☐ b. Funding will be requested in the Governor's Budget Act of ________

Fiscal Year: ________

☐ 2. Additional expenditures in the current State Fiscal Year which are NOT reimbursable by the State. (Approximate) (Pursuant to Section 6 of Article XIII B of the California Constitution and Sections 17500 et seq. of the Government Code).

$ ________

Check reason(s) this regulation is not reimbursable and provide the appropriate information:

☐ a. Implements the Federal mandate contained in ________

☐ b. Implements the court mandate set forth by the ________ Court.

Case of: ________ vs. ________

☐ c. Implements a mandate of the people of this State expressed in their approval of Proposition No. ________

Date of Election: ________

☐ d. Issued only in response to a specific request from affected local entity(s).

Local entity(s) affected: ________

☐ e. Will be fully financed from the fees, revenue, etc. from: ________

Authorized by Section: ________ of the ________ Code;

☐ f. Provides for savings to each affected unit of local government which will, at a minimum, offset any additional costs to each;

☐ g. Creates, eliminates, or changes the penalty for a new crime or infraction contained in ________

☐ 3. Annual Savings. (approximate)

$ ________

☐ 4. No additional costs or savings. This regulation makes only technical, non-substantive or clarifying changes to current law regulations.

☒ 5. No fiscal impact exists. This regulation does not affect any local entity or program.

☐ 6. Other. Explain ________

Instructions and Code Citations:
SAM Section 6601-6616

FISCAL IMPACT STATEMENT (CONTINUED)

B. FISCAL EFFECT ON STATE GOVERNMENT *Indicate appropriate boxes 1 through 4 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year. (Approximate)

$ ______________________

It is anticipated that State agencies will:

☐ a. Absorb these additional costs within their existing budgets and resources.

☐ b. Increase the currently authorized budget level for the ______________ Fiscal Year

☐ 2. Savings in the current State Fiscal Year. (Approximate)

$ ______________________

☒ 3. No fiscal impact exists. This regulation does not affect any State agency or program.

☐ 4. Other. Explain ______________________

C. FISCAL EFFECT ON FEDERAL FUNDING OF STATE PROGRAMS *Indicate appropriate boxes 1 through 4 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year. (Approximate)

$ ______________________

☐ 2. Savings in the current State Fiscal Year. (Approximate)

$ ______________________

☒ 3. No fiscal impact exists. This regulation does not affect any federally funded State agency or program.

☐ 4. Other. Explain ______________________

FISCAL OFFICER SIGNATURE	DATE
[Signed] D. Farrell, Staff Services Manager, CDFW Budget Branch	June 19, 2019

The signature attests that the agency has completed the STD. 399 according to the instructions in SAM sections 6601-6616, and understands the impacts of the proposed rulemaking. State boards, offices, or departments not under an Agency Secretary must have the form signed by the highest ranking official in the organization.

AGENCY SECRETARY	DATE
[Signed] Melissa A. Miller-Henson, Acting Executive Director, FGC	July 16, 2019

Finance approval and signature is required when SAM sections 6601-6616 require completion of Fiscal Impact Statement in the STD. 399.

DEPARTMENT OF FINANCE PROGRAM BUDGET MANAGER	DATE

Proposed regulation: possession of nongame animals (nutria)

California Fish and Game Commission Meeting
August 7, 2019
Presented by Valerie Cook
Nutria Eradication Program, CDFW

Overview

- Nutria eradication efforts
- Regulation of live nutria possession
- Proposed ban on live nutria possession

Nutria eradication

- Nutria (*Myocastor coypus*): one of the world's worst invasive species
- Rediscovered in California in 2017
- Department is lead agency for statewide, multi-agency eradication campaign

Current law and regulations: possession of nongame animals

- Nongame mammals may not be taken or possessed except as provided in FGC or regulations adopted by the commission. (F&GC § 4150)

- Any nongame bird or mammal that has been legally taken pursuant to this chapter may be possessed. (Section 473, Title 14, CCR)

Current law and regulations: possession of nongame animals

- Multiple regulatory permits allowing collection, possession of live nutria
- Department is obligated to issue permits

Proposed regulation: possession of nongame animals

- Proposed change creates subsection Section 473(b), Title 14, CCR:

  "It is unlawful to possess live nutria (Myocastor coypus), and the Department shall not issue any permit authorizing possession of any live nutria."

- Authorizes Department to deny applications to possess live nutria

Summary

- Regulation reduces potential for future, additional introductions
- Regulation supports State's and Department's extensive eradication efforts for protection of California's resources

11. DELTA FISHERIES MANAGEMENT POLICY

Today's Item **Information** ☐ **Action** ☒

Discuss the potential adoption of a Delta Fisheries Management Policy and compatibility of the FGC Striped Bass Policy.

Summary of Previous/Future Actions

• Delta Fisheries Forum	May 24, 2017; Sacramento
• WRC discussion	Sep 20, 2018; WRC, Sacramento
• WRC discussion	Jan 10, 2019; WRC, Ontario
• WRC discussion and recommendation	May 16, 2019; WRC, Sacramento
• FGC accepted WRC recommendation to schedule	Jun 12-13, 2019; Redding
• **Today's discussion**	**Aug 7-8, 2019; Sacramento**

Background

In Jun 2016, FGC received a regulation change petition (Tracking Number 2016-011) from the Coalition for a Sustainable Delta and others requesting to increase the bag limit and reduce the minimum size limit for striped bass and black bass in the Sacramento-San Joaquin Delta (Delta) and rivers tributary to the Delta. The expressed intent of the petition was to reduce predation by non-native bass on fish that are native to the Delta and listed as threatened or endangered under the federal or California endangered species acts, including winter-run and spring-run Chinook salmon, Central Valley steelhead, and delta smelt.

While the regulation change petition was formally withdrawn prior to FGC action, FGC requested that WRC schedule a discussion to explore the issue more comprehensively; the request also included a review of the existing FGC Striped Bass Policy that was adopted in 1996 and focuses on restoring and maintaining striped bass for recreational fishing opportunity (Exhibit 6). FGC staff was directed to hold a half-day forum focused on the State's vision for managing fisheries in the Delta for the benefit of native fish species and sport fisheries, implementation of the State's vision, and soliciting stakeholder input on potential actions FGC could consider related to this topic.

Held in May 2017, the forum was publicized and open to the public. The forum included a state agency panel discussion, an overview of FGC's policies and regulations for sport fisheries in the Delta, and a full group discussion. The discussion included two presentations by representatives for the original petition, consistent with direction provided by FGC. One of the recommendations that emerged from that forum was FGC adoption of a policy for fisheries management in the Delta that would provide science-based guidance to balance native fish needs with sport fishing opportunities in management decisions. The Coalition for a Sustainable Delta offered a proposed draft policy which, together with stakeholder and DFW input, formed the basis for the initial draft policy.

At its Sep 2018, Jan 2019, and May 2019 meetings, WRC discussed the draft policy and in May developed a recommendation that FGC schedule consideration of the draft policy. At its Jun

2019 meeting, FGC received the draft Delta Fisheries Management Policy advanced from WRC (Exhibit 5). At that meeting and following, stakeholders raised several significant issues with the draft policy. Following considerable public comment regarding the draft policy and current Striped Bass Policy, FGC accepted WRC's recommendation and directed staff to add the draft policy to the Aug 2019 meeting for discussion.

At this time, staff believes that additional discussions between stakeholders and staff of DFW and FGC are warranted to explore how to resolve the identified issues before FGC considers the draft Delta Fisheries Management Policy and any potential changes to the FGC Striped Bass Policy. Postponing discussion would allow dialogue to proceed and give additional stakeholders the chance to participate in ongoing discussions. Staff recommends that FGC consider new draft policies (based on discussions with stakeholders) at its Dec 2019 meeting in Sacramento, which will facilitate participation by stakeholders from in and around the Delta. If approved, FGC staff will provide a progress update at FGC's Oct 2019 meeting.

Significant Public Comments

1. The American Sportfishing Association and Coastside Fishing Club ask FGC to focus on the root causes of poor Delta health and oppose any effort to reduce long-term recreational fishing opportunities (Exhibit 1).
2. The California Sportfishing League emphasizes the economic importance of striped bass, states that predation from non-native game fish in the Delta is a "red herring", and opposes a repeal of the FGC Striped Bass Policy. The league states that reductions in fishing opportunity run counter to the State's R3 project and ask that discussions be scheduled near the greater Sacramento area (Exhibit 2).
3. The Northern California Guides and Sportsmen's Association states that predation on salmonid species is a minor stressor. The association asks that the item be tabled until Dec to allow for ongoing discussions to ensue, and that any further FGC conversations take place in the vicinity of the potential impacts of the draft Delta Fisheries Management Policy (Exhibit 3).
4. The Congressional Sportsmen's Foundation states that striped bass contribute to a healthy Delta ecosystem and that predation is not a significant factor driving Delta fish population abundances. They oppose the repeal of the Striped Bass Policy (Exhibit 4).

Recommendation

FGC staff: Postpone discussion of the draft policy to the Dec 2019 FGC meeting to allow FGC and DFW staff time to work with stakeholders on ways to address the issues that have been raised.

Exhibits

1. Letter from the American Sportfishing Association and Coastside Fishing Club, received Jul 25, 2019
2. Letter from the California Sportfishing League, received July 25, 2019
3. Letter from the Northern California Guides and Sportsmen's Association, received July 25, 2019

4. Letter from the Congressional Sportsmen’s Foundation, received July 25, 2019
5. Draft Delta Fisheries Management Policy, revised Aug 1, 2019
6. FGC Striped Bass Policy, adopted Apr 5, 1996

Motion/Direction

Moved by ________________ and seconded by ________________ that the Commission postpones discussion of the draft Delta Fisheries Management Policy and Commission’s Striped Bass Policy until the December 2019 meeting.

Cornman, Ari@FGC

From: California Fish and Game Commission <fgc@fgc.ca.gov>
Sent: Thursday, September 26, 2019 1:20 PM
To: Cornman, Ari@FGC
Subject: Corrected: September 30 Delta Fisheries Management Policy meeting

California
Fish and Game Commission

www.fgc.ca.gov

Thank you to those who noticed an error in our previous message regarding the Delta Fisheries Management Policy meeting. Please see the corrected message below with functioning links.

The California Fish and Game Commission invites stakeholders to participate in a meeting to discuss a potential new Delta Fisheries Management Policy and the Commission's existing Striped Bass Policy.

Date: September 30, 2019
Time: 4:00 p.m.
Location: Natural Resources Building
1416 Ninth Street, Room 1320
Jim Kellogg Conference Room
Sacramento, CA 95814

Webex information for remote participation:
https://cawildlife.webex.com/cawildlife/j.php?MTID=mf2a4d6e56c9cefa95e71e2727639afe1
Meeting Number 967 141 617

Join by phone:
1-877-402-9753 Call-in toll-free number (ATT Audio Conference)
1-636-651-3141 Call-in number (ATT Audio Conference)
Access Code 832 431 0

The discussion will help inform revisions to the draft delta policy and the current striped bass policy, which are expected to be considered at the Commission's December 11-12, 2019 meeting. Draft versions of the policies will be available later this week at http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=174526&inline.

Please contact staff at (916) 653-4899 or fgc@fgc.ca.gov if you have any questions.

Sincerely,

Ari Cornman
Wildlife Advisor
California Fish and Game Commission
Every Californian should conserve water. Learn how at: SaveOurWater.com

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CALIFORNIA FISH AND GAME COMMISSION PETITIONS FOR REGULATION CHANGE - ACTION

Revised 9/27/2019

FGC - California Fish and Game Commission DFW - California Department of Fish and Wildlife WRC - Wildlife Resources Committee MRC - Marine Resources Committee

Grant: FGC is willing to consider the petitioned action through a process Deny: FGC is not willing to consider the petitioned action Refer: FGC needs more information before deciding whether to grant or deny

General Petition Information					FGC Action			Additional Information
Tracking No.	**Date Received**	**Name of Petitioner**	**Subject of Request**	**Short Description**	**FGC Receipt Scheduled**	**FGC Action Scheduled**	**Staff Recommendation**	**Marine or Wildlife?**
2019-013	6/10/2019	Douglas R. Alton	Allow falconers and raptor propagators to receive non-releasable raptors	Add licensed falconers and federally permitted raptor propagators to the list of legal recipients for non-releasable raptors from licensed rehabilitation facilities.	8/7-8/2019	10/9-10/2019	DENY: This peition is substantively the same as petition #2016-14, which was referred to DFW and is still under consideration.	Wildlife
2019-016 AM 1	7/31/2019	Preston Taylor	Establish spring bear hunting	Institute a spring bear hunting season, which could be limited to wilderness areas or zones with high bear densities.	8/7-8/2019	10/9-10/2019	DENY: Management complexities would lead to enforcement problems and public confusion. There is also a risk of harming sows with cubs during that season, resulting in orphaned cubs.	Wildlife
2019-017 AM 1	7/31/2019	Preston Taylor	Open an archery season for take of bear and deer in Marble Mountain and Trinity Alps	Institute a traditional archery equipment season for deer and bear in the Marble Mountain Wilderness Area and Trinity Alps Wilderness Area.	8/7-8/2019	10/9-10/2019	DENY: This would require redistribution of permits from existing season, and traditional archery gear is already authorized during regular season.	Wildlife
2019-018	7/10/2019	Pat Wright	Exempt ferrets from list of restricted species	Add domestic ferrets under family Mustelidae as an exception to the list of restricted species.	8/7-8/2019	10/9-10/2019	DENY: This item was the subject of petition 2016-008, denied by FGC in Oct 2016. The rationale for that denial is the same here. A copy of the previous memo is provided as Exhibit A6.	Wildlife

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, 1416 Ninth Street, Suite 1320, Sacramento, CA 95814 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section l). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 6534899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct Responses for Section I should not exceed five pages

1. Person or organization requesting the change (Required)

   Name of primary contact person: Douglas R Alton

   Address: [redacted]

   Telephone number: [redacted]

   Email address: [redacted]

2. Rulemaking Authority (Required) - Reference to the statutory or constitutional authority of the Commission to take the action requested: Fish and Game Code Section 200

3. Overview (Required) - Summarize the proposed changes to regulations: Add licensed falconers and federally permitted raptor propagators to the list of legal recipients for non-releasable raptors from licensed rehabilitation facilities.

4. Rationale (Required) - Describe the problem and the reason for the proposed change: Non-releasable raptors are often euthanized if not placed, which is a waste of a public resource. Non-releasable raptors will be given a second chance at life with a licensed falconer or federally permitted raptor propagator.

SECTION Il: Optional Information

5. Date of Petition: 06/10/19

6. Ca Category of Proposed Change
- ☐ Sport Fishing
- ☐ C] Commercial Fishing
- ☐ Hunting
- ☒ Other, please specify: Falconry / Rehab.

7. The proposal is to: (To determine section number(s), see current year regulation booklet or https://qovt.west/aw.com/calreas)

   Amend Title 14 Section(s):679.(f) (4) Possession of Wildlife and Wildlife Rehabilitation

   Add New Title 14 Section(s): Click here to enter text.

   Repeal Title 14 Section(s): Click here to enter text.

8. If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition Click here to enter text. Or Not applicable.

9. Effective date: If applicable, identify the desired effective date of the regulation. If the proposed change requires immediate implementation, explain the nature of the emergency: Within reason 01/01/2020

1 0. Supporting documentation: Identify and attach to the petition any information supporting the proposal including data, reports and other documents: Click here to enter text.

1 1 . Economic or Fiscal Impacts: Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing: None

12. Forms: If applicable, list any forms to be created, amended or repealed:
Click here to enter text.

SECTION 3: FCC Staff only

Date received: Received by email on Monday, June 10, 2019 at 9:01 AM.

FGC staff action:

- [x] Accept - complete
- [ ] Reject - incomplete
- [ ] Reject - outside scope of FGC authority
- [ ] Denied by FGC
- [ ] Denied - same as petition
- [ ] Granted for consideration of regulation change

From: FGC
Sent: Wednesday, July 31, 2019 9:19 AM
To: Kinchak, Sergey@FGC; Cornman, Ari@FGC
Subject: Fw: Traditional Archery (2019-17) and Spring Bear Hunting (2019-16) Seasons Petitions
Attachments: Spring bear hunting petition..docx; Traditional Archery equipment season petition.docx

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From: Preston Taylor
Sent: Wednesday, July 31, 2019 09:11 AM
To: FGC <FGC@fgc.ca.gov>
Subject: Traditional Archery (2019-17) and Spring Bear Hunting (2019-16) Seasons Petitions

Hello FGC,
I would like to submit an amendment with new authority codes to my two petitions: Traditional Archery Season 2019-17 and Spring Bear Hunting 2019-16 (both are attached). Also, I'd like to request a waiver of the 10-day response period please.

Let me know if you need any more information, and thank you for taking the time to review my requests. I look forward to speaking with you about these petitions.
Preston Taylor

Tracking Number: (2019-16 AM 1)

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, 1416 Ninth Street, Suite 1320, Sacramento, CA 95814 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
   Name of primary contact person: Preston Taylor
   Address:
   Telephone number:
   Email address:

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: CCR T14-365 (bear). Authority cited: Sections 86, 200, 202 and 203, Fish and Game Code. Reference: Sections 200, 202, 203, 203.1 and 207, Fish and Game Code.

3. **Overview (Required) -** Summarize the proposed changes to regulations: Institute a spring bear hunting season. It could be limited to existing Wilderness Areas, or zones with high bear densities.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: Hunting is a healthy and productive activity, which contrasts this age of electronics and sedentary lifestyles. Bear hunting provides great meat, lard, and hides. Spring bear hunting would provide a new outdoor reacreational opportunity for California hunters. Lots of hunters travel out of this state to hunt bears elsewhere in the west in the spring.

SECTION II: Optional Information

5. **Date of Petition:** July 10, 2019

6. **Category of Proposed Change**
   ☐ Sport Fishing
   ☐ Commercial Fishing

☐ Hunting
☐ Other, please specify: spring bear hunting

7. **The proposal is to:** (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)
☐ Amend Title 14 Section(s): 365 bear hunting
☐ Add New Title 14 Section(s):
☐ Repeal Title 14 Section(s):

8. **If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition** Not applicable.
Or ☐ Not applicable.

9. **Effective date**: If applicable, identify the desired effective date of the regulation.
If the proposed change requires immediate implementation, explain the nature of the emergency:

10. **Supporting documentation:** Identify and attach to the petition any information supporting the proposal including data, reports and other documents:

11. **Economic or Fiscal Impacts:** Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing: Increased bear tag sales. Increased economic impact in the spring time.

12. **Forms:** If applicable, list any forms to be created, amended or repealed:

SECTION 3: FGC Staff Only

Date received: Received by email on Wednesday, July 31, 2019 at 9:19 AM

FGC staff action:
☑ Accept - complete
☐ Reject - incomplete
☐ Reject - outside scope of FGC authority
Tracking Number 2019-16 AM 1

Date petitioner was notified of receipt of petition and pending action: August 1, 2019

Meeting date for FGC consideration: October 9-10, 2019

FGC action:
☐ Denied by FGC
☐ Denied - same as petition ____________________
Tracking Number
☐ Granted for consideration of regulation change

From: FGC
Sent: Wednesday, July 31, 2019 9:19 AM
To: Kinchak, Sergey@FGC; Cornman, Ari@FGC
Subject: Fw: Traditional Archery (2019-17) and Spring Bear Hunting (2019-16) Seasons Petitions
Attachments: Spring bear hunting petition..docx; Traditional Archery equipment season petition.docx

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From: Preston Taylor [redacted]
Sent: Wednesday, July 31, 2019 09:11 AM
To: FGC <FGC@fgc.ca.gov>
Subject: Traditional Archery (2019-17) and Spring Bear Hunting (2019-16) Seasons Petitions

Hello FGC,
I would like to submit an amendment with new authority codes to my two petitions: Traditional Archery Season 2019-17 and Spring Bear Hunting 2019-16 (both are attached). Also, I'd like to request a waiver of the 10-day response period please.

Let me know if you need any more information, and thank you for taking the time to review my requests. I look forward to speaking with you about these petitions.
Preston Taylor

Tracking Number: (2019-17 AM 1)

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Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
   Name of primary contact person: Preston Taylor
   Address:
   Telephone number:
   Email address: [redacted]

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: CCR T14-354 (archery equipment regulations); CCR T14-361 (archery deer hunting); CCR T14-366 (archery bear hunting). Authority cited: Sections 200, 203, 240 and 265, Fish and Game Code. Reference: Sections 200, 203, 203.1, 265, 2005 and 4370, Fish and Game Code; Authority cited: Sections 200, 203, 265 and 4370, Fish and Game Code. Reference: Sections 200, 203, 203.1, 255, 265 and 4370, Fish and Game Code.; Authority cited: Sections 200, 202 and 203, Fish and Game Code. Reference: Sections 200, 202, 203, 203.1 and 207, Fish and Game Code.

3. **Overview (Required) -** Summarize the proposed changes to regulations: Institute a Traditional Archery equipment season for deer and bear in the Marble Mountain Wilderness and Trinity Alps Wilderness. Traditional Archery equipment includes: selfbows (bows carved from trees), laminated longbows and recurves, and wood arrows. Proposed dates for the season, either: 1) Two weeks prior to the start of the regular archery season in the B-zones, or; 2) Two weeks after the close of the general B-zone season.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: The archery season was originally intended to provide hunters with a time for greater challenge and to hunt with less people in the woods. The advent of modern archery gear has made the learning curve much faster, thus the woods during the "primitive" weapons season is getting more crowded. The origins of sport-archery hunting is rooted right here in northern California: Ishi, Dr. Saxton Pope, and Art Young proved that hunting with homemade archery tackle was effective on all North American big game, and started an awakening in the world of archery, which eventually spread to Howard Hill and Fred Bear and

led to the creation of a primitive weapons hunt: the Archery Only season. Those of us who craft selfbows and wood arrows, who hunt with longbows and recurves, and who spend countless days in the field trying to get within 10 yards of a wary buck, we find ourselves overwhelmed and overpowered by the modern archery industry. The romance and difficulty of bow-hunting has become watered down thanks to rangefinders, GPS sights, Bluetooth arrow nocks, etc. I propose the Traditional Archery season be limited to two wilderness areas: the Marble Mountains and Trinity Alps Wilderness. These are already considered primitive areas; therefore, hunting with traditional tackle fits well with the intentions of the Wilderness Act. Hunting with Traditional Archery tackle is no less ethical than other hunting methods. I have killed a number of big game animals with my longbow and watched them die in less than 5 seconds, which is quicker than some rifle killed animals. The new season could be held prior to the current archery season or after the close of the general season in the B-zones.

SECTION II: Optional Information

5. **Date of Petition:** July 10, 2019

6. **Category of Proposed Change**
☐ Sport Fishing
☐ Commercial Fishing
☐ Hunting
☐ Other, please specify: Archery hunting

7. **The proposal is to:** (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)
☐ Amend Title 14 Section(s):
☐ Add New Title 14 Section(s): 354, 361, 366. Create a new Traditional Archery equipment season.
☐ Repeal Title 14 Section(s):

8. **If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition** Not applicable.
Or ☐ Not applicable.

9. **Effective date**: If applicable, identify the desired effective date of the regulation.
If the proposed change requires immediate implementation, explain the nature of the emergency:

10. **Supporting documentation:** Identify and attach to the petition any information supporting the proposal including data, reports and other documents: Oregon Department of Fish and Wildlife has instituted 2 Traditional Archery equipment seasons, and is considering more opportunities.

11. **Economic or Fiscal Impacts:** Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing: There has been a resurgence of interest in traditional archery since the advent of movies with archers in them. The new traditional equipment

season could attract new hunters, which could raise license sales. A longer season will result in economic growth for small towns and businesses around the hunting unit.

12. Forms: If applicable, list any forms to be created, amended or repealed:

SECTION 3: FGC Staff Only

Date received: Received by email on Wednesday, July 31, 2019 at 9:19 AM

FGC staff action:

- ☑ Accept - complete
- ☐ Reject - incomplete
- ☐ Reject - outside scope of FGC authority

Tracking Number 2019-017 AM 1

Date petitioner was notified of receipt of petition and pending action: August 1, 2019

Meeting date for FGC consideration: October 9-10, 2019

FGC action:

- ☐ Denied by FGC
- ☐ Denied - same as petition ______________________
  Tracking Number
- ☐ Granted for consideration of regulation change

Tracking Number: (2019-018)

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, 1416 Ninth Street, Suite 1320, Sacramento, CA 95814 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
Name of primary contact person: Pat Wright
Address: [redacted]
Telephone number: [redacted]
Email address: [redacted]

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: **2118.** It is unlawful to import, transport, possess, or release alive into this state, except under a revocable, nontransferable permit as provided in this chapter and the regulations pertaining thereto, **any wild animal** of the following species: Mammals of the orders Primates, Edentata, Dermoptera, Monotremata, Pholidota, Tubulidentata, Proboscidea, Perissodactyla, Hyracoidea, Sirenia and Carnivora are restricted for the welfare of the animals, except animals of the families Viverridae and **Mustelidae** in the order Carnivora are restricted because suchanimals are undesirable and a menace to native wildlife, the agricultural interests of the state, or to the public health or safety.

3. **Overview (Required) -** Summarize the proposed changes to regulations: Domestic ferrets do not belong on a list of **Wild Animals**. It is 100% inaccurate and makes any chance at legislation unlikely.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: Ferrets are domestic. Other organizations and elected officials are using this classification: that the California Fish and Game Commission (The "Experts") classify domestic ferrets as wild animals as their justification to support a continued ban on a domestic animals.
The Fish and Game Commission is using objections by "environmentalists" as a reason not to act on reclassification, but the Sierra Club is using Fish and Game's classification of domestic ferrets as being wild to continue their opposition to ferret legalization.

SECTION II: Optional Information

5. **Date of Petition: July 10th, 2019**

6. **Category of Proposed Change**
   ☐ Sport Fishing
   ☐ Commercial Fishing
   ☐ Hunting
   ☒ Other, please specify: non marine animals

7. **The proposal is to:** (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)
   ☐ Amend Title 14 Section(s):
   ☐ Add New Title 14 Section(s):
   ☐ Repeal Title 14 Section(s):

8. **If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition** 2016-008
   Or ☐ Not applicable.

9. **Effective date**: If applicable, identify the desired effective date of the regulation.
   If the proposed change requires immediate implementation, explain the nature of the emergency:

10. **Supporting documentation:** Identify and attach to the petition any information supporting the proposal including data, reports and other documents: Attached with this email are articles from Wikipdedia, PETA and ADW all claiming domestic ferrets are domestic animals.

11. **Economic or Fiscal Impacts:** Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing: Charge a fee necessary to cover the cost of issuing permits.

12. **Forms:** If applicable, list any forms to be created, amended or repealed:

SECTION 3: FGC Staff Only

Date received: Received by email on Wednesday, July 10, 2019 at 9:58 AM.

FGC staff action:
☑ Accept - complete
☐ Reject - incomplete
☐ Reject - outside scope of FGC authority

Date petitioner was notified of receipt of petition and pending action: August 6, 2019

Meeting date for FGC consideration: October 9-10, 2019

FGC action:

- ☐ Denied by FGC
- ☐ Denied - same as petition ____________________
  Tracking Number
- ☐ Granted for consideration of regulation change

Received by email on Wednesday, July 10, 2019 at 9:58 AM as a supporting letter to petition 2019-018

Kinchak, Sergey@FGC

From:	FGC
Sent:	Wednesday, July 10, 2019 9:58 AM
To:	Cornman, Ari@FGC
Cc:	Kinchak, Sergey@FGC
Subject:	Fw: Petition for Regulation Change
Attachments:	07-10-9 Petition asking DFG to issue permits.docx; 071019-ADW_ Mustela putorius furo_ INFORMATION.pdf; 071019-Wikipedia.pdf; 071019-Facts on Ferrets _ PETA.pdf

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From: [redacted]
Sent: Wednesday, July 10, 2019 08:28 AM
To: FGC
Subject: Petition for Regulation Change

LegalizeFerrets.org
PO Box 1480
La Mesa, CA 91944
619-303-0645 [redacted]
California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090
July 10, 2019
Re: Petition To The California Fish and Game Commission for Regulation Change
Dear Fish and Game Mangers,
Please consider this supporting letter to the also attached petition.
We are asking you to not refer to domestic ferrets as wild animals.
When we previously asked the commission to remove ferrets from the list of prohibited wildlife I was told by Mr. Sklar that it was more complicated than I realized. That "environmentalists" would sue the Commission if they acted upon it. He advised me to get the support of a legislator because legislation is not subject to CEQA.

We have tried on many fronts to gain the support of a legislator. Support for ferret legalization is hampered by opposition from the Sierra Club among other groups. Here is one comment:

"Sierra Club has long opposed holding wild animals as pets, but particularly when those animals could present a problem if they accidentally or intentionally are introduced into the state's natural areas. There are many, many examples of exotic critters that have become problems in California after being introduced into the wild. One that I am very familiar with is the bull frog, which has helped push out other amphibian species in certain habitats since its introduction in the 19th century."

Kathryn Phillips kathryn.phillips@sierraclub.org

We are asking the Sierra Club to reevaluate their position, but they have not yet responded to us. However, an out of state member received this response:

I have checked with the chairman of the Sierra Club California conservation committee and he reports that our position is to follow the lead of the California Fish and Wildlife Department, which is concerned that if pet ferrets were to escape, they would threaten native wildlife. The Sierra Club position is to support the state wildlife professionals. If the agency changes its position and finds that ferrets pose no threat the Sierra Club will consider changing its position at that time. I'm very sorry that you feel you must resign your membership over this issue when there is so much else we agree upon.
Bruce Hamilton <bruce.hamilton@sierraclub.org>

We thus have a circular reference. You, the Fish and Game Commission, have told us you won't move on ferrets for fear of being sued by "the environmentalists." The Sierra Club, the nation's premier environmental organization, will not move on the issue until the California Fish and Game Commission alters the classification of domestic ferrets as wild animals.

This isn't fair to us, ferret enthusiasts. There are no studies or reports that show the domestic ferret as wild. The domestication process is quite objective – by every measure ferrets are domestic.

We are chipping away at this slowly. This is a request for your agency to quit referring to domestic ferrets as wild animals which will help us find a legislative sponsor.

Sincerely,

Pat Wright

Received by email on Wednesday, July 10, 2019 at 9:58 AM as attachment 1 to petition 2019-018

Animal Diversity Web

University of Michigan Museum of Zoology

Mustela putorius furo domestic ferret

Facebook Twitter

By Jessica Duda

Geographic Range

Currently almost no progress has been made in determining the center of the domestication of ferrets. It is thought that ferrets may have been domesticated from native European polecats (*Mustela putorius*). There is evidence of domestic ferrets in Europe over 2500 years ago. Currently domestic ferrets are found around the world in homes as pets. In Europe, people sometimes use ferrets for hunting, which is known as ferreting. (Davidson 1999, Schilling 2000)

Biogeographic Regions: nearctic (introduced) ; palearctic (native) ; oriental (introduced) ; ethiopian (introduced) ; neotropical (introduced) ; australian (introduced)

Habitat

The native habitat of domestic ferrets were forested and semi-forested habitats near water sources. Domestic ferrets are kept as pets or as working animals in human habitations.

Classification

Kingdom
Animalia
animals

Phylum

Other Habitat Features: urban ; suburban ; agricultural

Physical Description

Domestic ferrets reach their adult size at one year old. A typical female domestic ferret weighs from 0.3 to 1.1 kg. Domestic ferrets exhibit sexual dimorphism. Male domestic ferrets can weigh from 0.9 to 2.7 kg, neutered males often weigh less than unaltered males. Domestic ferrets have a long and slender body. Females are typically 33 to 35.5 cm long and males are 38 to 40.6 cm long. Average tail length is 7.6 to 10 cm. Domestic ferrets have large canine teeth and 34 teeth total. Each paw has a set of five, non-retractable claws.

Domestic ferrets have been bred for a large variety of fur colors and patterns. The seven common fur colors are called: sable, silver, black sable, albino, dark-eyed white, cinnamon, and chocolate. The most common of these colors is sable. Examples of pattern types are: Siamese or pointed patterned, panda, Shetlands, badgers, and blazes.

Aside from selection towards particular fur colors, domestic ferrets closely resemble their wild ancestors, European polecats (*Mustela putorius*).

(Schilling 2000)

Other Physical Features: endothermic ; homoiothermic ; bilateral symmetry

Sexual Dimorphism: male larger

Range mass
0.3 to 2.7 kg
0.66 to 5.95 lb

Range length
33.0 to 40.6 cm
12.99 to 15.98 in

Reproduction

Male domestic ferrets will mate with as many females as they have access to.

Mating System: polygynous

Male ferrets have a hooked penis. After penetration of the female, they can't be separated until the male releases. Males will also bite the back of the female's neck while mating. Domestic

Chordata
chordates

Subphylum
Vertebrata
vertebrates

Class
Mammalia
mammals

Order
Carnivora
carnivores

Family
Mustelidae
badgers, otters, weasels, and relatives

Genus
Mustela
ermines, ferrets, minks, and weasels

Species
Mustela putorius
European polecat

Subspecies
Mustela putorius furo
domestic ferret

ferrets have a seasonal polyestrous cycle. Male domestic ferrets go into rut between December and July. Females go into heat between March and August. Males are ready to breed when they develop a discolored, yellowish undercoat. An increase in the oil production of the skin glands is what causes the discolored undercoat.

A female in estrous is identifiable by a swollen pink vulva due to an increase in estrogen. Females can go into lactational estrous on some occasions. Lactational estrus occurs if the litter size is less than 5 kits. Lactational estrus is when the female will go back into estrous while lactating the litter that she just had. Healthy domestic ferrets can have up to three successful litters per year, and up to 15 kits. Gestation length is about 42 days. Young domestic ferrets are altricial at birth, and need about 8 weeks of parental care. Kits are born deaf and have their eyes closed. Newborns typically weigh about 6 to 12 grams. Baby incisors appear about 10 days after birth. The kits eyes and ears open when they are 5 weeks old. Weaning of the kits is done while they are 3-6 weeks old. At 8 weeks, kits have 4 permanent canine teeth and are capable of eating hard food. This is often the time that breeders let the kits go to new owners. Female kits will then reach sexual maturity at 6 months old. (Kaytee 2001, Schilling 2000)

> **Key Reproductive Features:** iteroparous ; seasonal breeding ; gonochoric/gonochoristic/dioecious (sexes separate) ; sexual ; fertilization (internal) ; viviparous

Breeding season
Breeding occurs between March and August.

Range number of offspring
15 (high)

Average gestation period
42 days

Range weaning age
3 to 6 weeks

Average age at sexual or reproductive maturity (female)
6 months

Average age at sexual or reproductive maturity (male)
6 months

Young domestic ferrets are cared for by their mothers until they are about 8 weeks of age.

Parental Investment: altricial ; female parental care

Lifespan/Longevity

Domestic ferrets will not survive long in the wild. As pets, they can live from 6-10 years. There are a few diseases and disorders that can shorten the life of domestic ferrets if not treated. Some of these diseases and disorders include: canine distemper, feline distemper, rabies, parasites, bone marrow suppression, insulinoma, adrenal gland disease, diarrhea, colds, flus, ringworm, heat stroke, urinary stones, and cardiomyopathy. (Kaytee 2001, MNAALAS date unknown, Schilling 2001)

Typical lifespan
Status: captivity
6 to 10 years

Behavior

A healthy domestic ferret will often sleep 18-20 hours per day. Domestic ferrets are naturally crepuscular, having activity periods during dawn and dusk. They will often change this activity period depending on when their owner is around to give them attention. Domestic ferrets are playful and fastidious. They will often interact with other pet ferrets, cats, and dogs in a friendly manner. Domestic ferrets will seek attention. They are naturally inquisitive and will tunnel into or under anything. They can be taught tricks and will respond to discipline. Domestic ferrets have an instinct to habitually urinate and defecate in the same places, and therefore can be trained to use a litter box.

Domestic ferrets use a variety of body language. Some of these behaviors are dancing, wrestling, and stalking. They will 'dance' when they are happy and excited, hopping in every direction. Wrestling is a behavior that includes two or more ferrets. They will roll around with each other, biting and kicking, usually in a playful manner. Stalking is sneaking up on a toy or other animal in a low crouched position. (MNAALAS date unknown, Schilling 2000)

Key Behaviors: crepuscular ; motile ; sedentary ; social

Communication and Perception

Domestic ferrets have many forms of verbal communication. They will 'dock' or 'cluck' as sounds of giddiness or excitement. They will 'screech' as a sign of terror, pain, or anger. They will 'bark' if they are very excited. Finally, a domestic ferret will 'hiss' if it is annoyed or very angry at another ferret or animal. (Schilling 2000)

Communication Channels: visual ; tactile ; acoustic ; chemical

Other Communication Modes: scent marks

Perception Channels: tactile ; chemical

Food Habits

Domestic ferrets are natural carnivores, and require a meat-like diet. Food for domestic ferrets should contain taurine and be composed of at least 20% fat and 34% animal protein. Most domestic ferrets are fed manufactured ferret, cat, or dog food. They can also be fed raw meat, but that alone is not sufficient. If they were in the wild, they would get nutrients from eating all parts of an animal, such as the liver, heart, and other organs. Sometimes domestic ferrets are fed supplements (like vitamins) to make up for nutritional requirements that commercial foods don't meet.

The metabolism of a domestic ferret is very high and food will travel through the digestive tract in 3-5 hours. Therefore, a domestic ferret will need to eat about 10 times each day. Domestic ferrets also have olfactory imprinting. What ever is fed to them for the first 6 months of their life is what they will recognize as food in the future. (Schilling 2000)

Primary Diet: carnivore (eats terrestrial vertebrates)

Predation

Domestic ferrets don't have any natural predators since they are domesticated. Predators such as hawks, owls, or larger carnivorous mammals would hunt them given the opportunity. Domestic ferrets on the other hand can be predators to certain animals. They have been known to kill pet birds. Domestic ferrets will also hunt rabbits and other small game when their owners use them for ferreting. There is also record of ferrets being used to control rodent populations on ships during the American revolutionary war. (Schilling 2000)

Ecosystem Roles

Because domestic ferrets do not inhabit natural ecosystems, they have no ecosystem roles.

Economic Importance for Humans: Positive

Domestic ferrets are popular pets. There are ferret breeders and ferret farms that raise ferrets for the pet trade, and many pet shops carry ferrets to sell. There are many other products that go along with a pet ferret including ferret food, ferret toys, ferret cages, ferret beds, and other commercial items designed specifically for ferrets. Ferrets have also been used in research. (Schilling, 2000)

> **Positive Impacts:** pet trade ; research and education

Economic Importance for Humans: Negative

Domestic ferrets, if not properly vaccinated or cared for, can harbor certain diseases that are transmissible to humans. Domestic ferrets have formed feral populations in some parts of the world and can be a serious pest of native birds and other wildlife.

> **Negative Impacts:** injures humans (carries human disease) ; causes or carries domestic animal disease

Conservation Status

Domestic ferrets are not listed on any conservation lists, because their populations are far from low. On the other hand, domestic ferrets have been used in efforts to build the populations of endangered species such as the black-footed ferret. Scientists have recently successfully completed a non-surgical embryo collection and transfer in domestic ferrets. This means that they took the embryo from one female and transferred it to another female with out using surgical procedures. This procedure resulted in live young with the domestic ferrets. This is significant because it can be modified to be used in black-footed ferrets. (Segelken 1996)

IUCN Red List
No special status

US Migratory Bird Act
No special status

US Federal List
No special status

CITES

No special status

Other Comments

Ferrets were likely domesticated from European polecats (*M. putorius furo*) over 2000 years ago. At this time it is likely that captive and wild ferrets/polecats continued to interbreed. Learn more about the wild relatives of domestic ferrets in our ADW account for *Mustela putorius* at: http://animaldiversity.ummz.umich.edu/accounts/mustela/m._putorius$narrative.html .

Contributors

Jessica Duda (author), University of Wisconsin-Stevens Point, Chris Yahnke (editor), University of Wisconsin-Stevens Point.

References

Animal Diversity WebMustela putorius [European polecat]http://animaldiversity.ummz.umich.edu/accounts/mustela/m._putorius.htmlSeptember 2, 2002

Davidson, A., J. Birks, H. Griffiths, A. Kitchener, D. Biggens. 1999. Hybridization and the phylogenetic relationship between polecats and the domestic ferret in Britain.. *Biological Conservation*: 155-161.

Kaytee, 2001. "Ferret Health" (On-line). Accessed 24 October 2001 at http://www.kaytee.com/smallanimals/ferrets/index.html.

Kaytee, 2001. "Ferret Vital Statistics" (On-line). Accessed 24 October 2001 at http://www.kaytee.com/smallanimals/ferrets/vital.html.

MNAALAS, unknown. "Ferret Facts" (On-line). Accessed 24 October 2001 at http://www.ahc.umn.edu/rar/MNAALAS/ferret.html.

Schilling, K. 2000. *Ferrets for Dummies*. California, USA.: IDG Books Worldwide Inc..

Segelken, R. 1996. Embryo transfer procedure offers hope for endangered species. *Cornell Chronicle*,.

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The ADW Team gratefully acknowledges their support.

Received by email on Wednesday, July 10, 2019 at 9:58 AM as attachment 2 to petition 2019-018

Ferret

Ferret	
	
Conservation status	
Domesticated	
Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Carnivora
Family:	Mustelidae
Genus:	*Mustela*
Species:	*M. putorius*
Subspecies:	***M. p. furo***
Trinomial name	
Mustela putorius furo Linnaeus, 1758	
Synonyms	
Mustela furo Linnaeus, 1758	

The **ferret** (*Mustela putorius furo*) is the domesticated form of the European polecat, a mammal belonging to the same genus as the weasel, *Mustela*, in the family Mustelidae.[1] Their fur is typically brown, black, white, or mixed. They have an average length of 51 cm (20 in), including a 13 cm (5.1 in) tail, weigh about 1.5–4 pounds (0.7–2 kg), and have a natural lifespan of 7 to 10 years.[2] Ferrets are sexually dimorphic predators, with males being substantially larger than females.

The history of the ferret's domestication is uncertain, like that of most other domestic animals, but it is likely that they have been domesticated for at least 2,500 years. They are still used for hunting rabbits in some parts of the world, but increasingly they are kept only as pets.

Being so closely related to polecats, ferrets easily hybridize with them, and this has occasionally resulted in feral colonies of polecat–ferret hybrids that have caused damage to native fauna, especially in New Zealand.[3] As a result, New Zealand and some other parts of the world have imposed restrictions on the keeping of ferrets.

Several other mustelids also have the word *ferret* in their common names, including the black-footed ferret, an endangered species.

Contents

Etymology

The name "ferret" is derived from the Latin *furittus*, meaning "little thief", a likely reference to the common ferret penchant for secreting away small items.[4] The Greek word *ictis* occurs in a play written by Aristophanes, *The Acharnians*, in 425 BC. Whether this was a reference to ferrets, polecats, or the similar Egyptian mongoose is uncertain.[5]

A male ferret is called a hob; a female ferret is a jill. A spayed female is a sprite, a neutered male is a gib, and a vasectomised male is known as a hoblet. Ferrets under one year old are known as kits. A group of ferrets is known as a "business",[6] or historically as a "busyness". Other purported collective nouns, including "besyness", "fesynes", "fesnyng", and "feamyng", appear in some dictionaries, but are almost certainly ghost words.[7]

Biology

Characteristics

Skull of a ferret

Ferrets have a typical mustelid body-shape, being long and slender. Their average length is about 50 cm (20 in) including a 13 cm (5.1 in) tail. Their pelage has various colorations including brown, black, white or mixed. They weigh between 0.7 and 2.0 kg (1.5 and 4.4 lb) and are sexually dimorphic as the males are substantially larger than females. The average gestation period is 42 days and females may have two or three litters each year. The litter size is usually between three and seven kits which are weaned after three to six weeks and become independent at three months. They become sexually mature at approximately six months and the average life span is seven to 10 years.[8][9] Ferrets are induced ovulators.[10]

Ferret profile

Behavior

Ferrets spend 14–18 hours a day asleep and are most active around the hours of dawn and dusk, meaning they are crepuscular.[11] Unlike their polecat ancestors, which are solitary animals, most ferrets will live happily in social groups. A group of ferrets is commonly referred to as a "business".[12] They are territorial, like to burrow, and prefer to sleep in an enclosed area.[13]

Like many other mustelids, ferrets have scent glands near their anus, the secretions from which are used in scent marking. Ferrets can recognize individuals from these anal gland secretions, as well as the sex of unfamiliar individuals.[14] Ferrets may also use urine marking for sex and individual recognition.[15]

As with skunks, ferrets can release their anal gland secretions when startled or scared, but the smell is much less potent and dissipates rapidly. Most pet ferrets in the US are sold descented (anal glands removed).[16] In many other parts of the world, including the UK and other European countries, de-scenting is considered an unnecessary mutilation.

If excited, they may perform a behavior called the "weasel war dance", characterized by frenzied sideways hops, leaps and bumping into nearby objects. Despite its common name, it is not aggressive but is a joyful invitation to play. It is often accompanied by a unique soft clucking noise, commonly referred to as "dooking".[17] When scared, ferrets will hiss; when upset, they squeak softly.[18]

Diet

Ferrets are obligate carnivores.[19] The natural diet of their wild ancestors consisted of whole small prey, including meat, organs, bones, skin, feathers, and fur.[20] Ferrets have short digestive systems and quick metabolism, so they need to eat frequently. Prepared dry foods consisting almost entirely of meat (including high-grade cat food, although specialized ferret food is increasingly available and preferable)[21] provide the most nutritional value and are the most convenient,[22] though some ferret owners feed pre-killed or live prey (such as mice and rabbits) to their ferrets to more closely mimic their natural diet.[23][24] Ferret digestive tracts lack a cecum and the animal is largely unable to digest plant matter.[25] Before much was known about ferret physiology, many breeders and pet stores recommended food like fruit in the ferret diet, but it is now known that such foods are inappropriate, and may in fact have negative ramifications on ferret health. Ferrets imprint on their food at around six months old. This can make introducing new foods to an older ferret a challenge, and even simply changing brands of kibble may meet with resistance from a ferret that has never eaten the food as a kit. It is therefore advisable to expose young ferrets to as many different types and flavors of appropriate food as possible.[26]

Dentition

Ferrets have four types of teeth (the number includes maxillary (upper) and mandibular (lower) teeth) with a dental formula of $\frac{3.1.4.1}{3.1.4.2}$:

- Twelve small incisor teeth (only 2–3 mm [$\frac{3}{32}$–$\frac{1}{8}$ in] long) located between the canines in the front of the mouth. These are used for grooming.
- Four canines used for killing prey.
- Twelve premolar teeth that the ferret uses to chew food—located at the sides of the mouth, directly behind the canines. The ferret uses these teeth to cut through flesh, using them in a scissors action to cut the meat into digestible chunks.
- Six molars (two on top and four on the bottom) at the far back of the mouth are used to crush food.


Ferret dentition

Health

Ferrets are known to suffer from several distinct health problems. Among the most common are cancers affecting the adrenal glands, pancreas, and lymphatic system. Viral diseases include canine distemper and influenza. Health problems can occur in unspayed females when not being used for breeding.[27] Certain health problems have also been linked to ferrets being neutered before reaching sexual maturity. Certain colors of ferret may also carry a genetic defect known as Waardenburg syndrome. Similar to domestic cats, ferrets can also suffer from hairballs and dental problems. Ferrets will also often chew on and swallow foreign objects which can lead to bowel obstruction.[28]


Male ferret

History of domestication

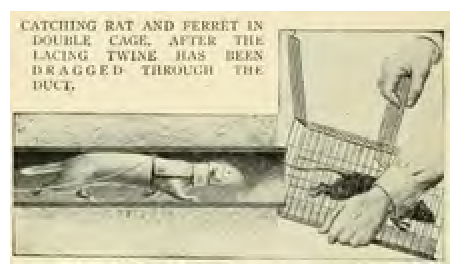
Women hunting rabbits with a ferret in the Queen Mary Psalter

In common with most domestic animals, the original reason for ferrets being domesticated by human beings is uncertain, but it may have involved hunting. According to phylogenetic studies, the ferret was domesticated from the European polecat (*Mustela putorius*), and likely descends from a North African lineage of the species.[29] Analysis of mitochondrial DNA suggests that ferrets were domesticated around 2,500 years ago. It has been claimed that the ancient Egyptians were the first to domesticate ferrets, but as no mummified remains of a ferret have yet been found, nor any hieroglyph of a ferret, and no polecat now occurs wild in the area, that idea seems unlikely.[30]

Ferrets were probably used by the Romans for hunting.[31][32]

Colonies of feral ferrets have established themselves in areas where there is no competition from similarly sized predators, such as in the Shetland Islands and in remote regions in New Zealand. Where ferrets coexist with polecats, hybridization is common. It has been claimed that New Zealand has the world's largest feral population of ferret-polecat hybrids.[33] In 1877, farmers in New Zealand demanded that ferrets be introduced into the country to control the rabbit population, which was also introduced by humans. Five ferrets were imported in 1879, and in 1882–1883, 32 shipments of ferrets were made from London, totaling 1,217 animals. Only 678 landed, and 198 were sent from Melbourne, Australia. On the voyage, the ferrets were mated with the European polecat, creating a number of hybrids that were capable of surviving in the wild. In 1884 and 1886, close to 4,000 ferrets and ferret hybrids, 3,099 weasels and 137 stoats were turned loose.[34] Concern was raised that these animals would eventually prey on indigenous wildlife once rabbit populations dropped, and this is exactly what happened to New Zealand's bird species which previously had had no mammalian predators.

Ferreting



Muzzled ferret flushing a rat, as illustrated in Harding's *Ferret Facts and Fancies* (1915)

For millennia, the main use of ferrets was for hunting, or *ferreting*. With their long, lean build, and inquisitive nature, ferrets are very well equipped for getting down holes and chasing rodents, rabbits and moles out of their burrows. Caesar Augustus sent ferrets or mongooses (named *viverrae* by Plinius) to the Balearic Islands to control the rabbit plagues in 6 BC.[35][36] In England, in 1390, a law was enacted restricting the use of ferrets for hunting to the relatively wealthy:

> it is ordained that no manner of layman which hath not lands to the value of forty shillings a year shall from henceforth keep any greyhound or other dog to hunt, nor shall he use ferrets, nets, heys, harepipes nor cords, nor other engines for to take or destroy deer, hares, nor conies, nor other gentlemen's game, under pain of twelve months' imprisonment.[37]

Ferrets were first introduced into the New World in the 17th century, and were used extensively from 1860 until the start of World War II to protect grain stores in the American West from rodents. They are still used for hunting in some countries, including the United Kingdom, where rabbits are considered a plague species by farmers.[38] The practice is illegal in several countries where it is feared that ferrets could unbalance the ecology. In 2009 in Finland, where ferreting was previously unknown, the city of Helsinki began to use ferrets to restrict the city's rabbit population to a manageable level. Ferreting was chosen because in populated areas it is considered to be safer and less ecologically damaging than shooting the rabbits.

As pets

In the United States, ferrets were relatively rare pets until the 1980s. A government study by the California State Bird and Mammal Conservation Program estimated that by 1996 about 800,000 domestic ferrets were being kept as pets in the United States.[39]

A ferret in a war dance jump.

Like many household pets, ferrets require a cage. For ferrets, a wire cage at least 18 inches long and deep and 30 inches wide or longer is needed. Ferrets cannot be housed in environments such as an aquarium because of the poor ventilation.[40] It is preferable that the cage have more than one level but this is not crucial. Usually two to three different shelves are used.

Regulation

- **Australia**: It is illegal to keep ferrets as pets in **Queensland** or the **Northern Territory**; in the **Australian Capital Territory** a licence is required.
- **Brazil**: They are allowed only if they are given a microchip identification tag and sterilized.
- **New Zealand**: It has been illegal to sell, distribute or breed ferrets in New Zealand since 2002 unless certain conditions are met.[41]
- **United States**: Ferrets were once banned in many US states, but most of these laws were rescinded in the 1980s and 1990s as they became popular pets.
  - Ferrets are still illegal in **California** under Fish and Game Code Section 2118;[42] and the California Code of Regulations,[43] although it is not illegal for veterinarians in the state to treat ferrets kept as pets.
  - Additionally, "Ferrets are strictly prohibited as pets under **Hawaii** law because they are potential carriers of the rabies virus";[44] the territory of **Puerto Rico** has a similar law.[45]
  - Ferrets are restricted by individual cities, such as **Washington, D.C.**, and **New York City**,[45] which renewed its ban in 2015.[46][47] They are also prohibited on many military bases.[45] A permit to own a ferret is needed in other areas, including Rhode Island.[48] Illinois and Georgia do not require a permit to merely possess a ferret, but a permit is required to breed ferrets.[49][50] It was once illegal to own ferrets in Dallas, Texas,[51] but the current Dallas City Code for Animals includes regulations for the vaccination of ferrets.[52] Pet ferrets are legal in Wisconsin, however legality varies by municipality. The city of **Oshkosh**, for example, classifies ferrets as a wild animal and subsequently prohibits them from being kept within the city limits. Also, an import permit from the state department of agriculture is required to bring one into the state.[53] Under common law, ferrets are deemed "wild animals" subject to strict liability for injuries they cause, but in several states statutory law has overruled the common law, deeming ferrets "domestic".[54]
- **Japan**: In **Hokkaido** prefecture, ferrets must be registered with the local government.[55] In other prefectures, no restrictions apply.

Other uses

Ferrets are an important experimental animal model for human influenza,[56][57] and have been used to study the 2009 H1N1 (swine flu) virus.[58] Smith, Andrews, Laidlaw (1933) inoculated ferrets intra-nasally with human naso-pharyngeal washes, which produced a form of influenza that spread to other cage mates. The human influenza virus (Influenza type A) was transmitted from an infected ferret to a junior investigator, from whom it was subsequently re-isolated.

- Ferrets have been used in many broad areas of research, such as the study of pathogenesis and treatment in a variety of human disease, these including studies into cardiovascular disease, nutrition, respiratory diseases such as SARS and human influenza, airway physiology,[59] cystic fibrosis and gastrointestinal disease.
- Because they share many anatomical and physiological features with humans, ferrets are extensively used as experimental subjects in biomedical research, in fields such as virology, reproductive physiology, anatomy, endocrinology, and neuroscience.[60]
- In the UK, ferret racing is often a feature of rural fairs or festivals, with people placing small bets on ferrets that run set routes through pipes and wire mesh. Although financial bets are placed, the event is primarily for entertainment purposes as opposed to 'serious' betting sports such as horse or greyhound racing.[61][62]

Terminology and coloring

Typical ferret coloration, known as a sable or polecat-colored ferret

Most ferrets are either albinos, with white fur and pink eyes, or display the typical dark masked sable coloration of their wild polecat ancestors. In recent years fancy breeders have produced a wide variety of colors and patterns. Color refers to the color of the ferret's guard hairs, undercoat, eyes, and nose; pattern refers to the concentration and distribution of color on the body, mask, and nose, as well as white markings on the head or feet when present. Some national organizations, such as the American Ferret Association, have attempted to classify these variations in their showing standards.[63]

There are four basic colors. The sable (including chocolate and dark brown), albino, dark eyed white (DEW) (also known as black eyed white or BEW), and the silver. All the other colors of a ferret are variations on one of these four categories.

Waardenburg-like coloring

White or albino ferret

Ferrets with a white stripe on their face or a fully white head, primarily blazes, badgers, and pandas, almost certainly carry a congenital defect which shares some similarities to Waardenburg syndrome. This causes, among other things, a cranial deformation in the womb which broadens the skull, white face markings, and also partial or total deafness. It is estimated as many as 75 percent of ferrets with these Waardenburg-like colorings are deaf.

White ferrets were favored in the Middle Ages for the ease in seeing them in thick undergrowth. Leonardo da Vinci's painting *Lady with an Ermine* is likely mislabelled; the animal is probably a ferret, not a stoat, (for which "ermine" is an alternative name for the animal in its white winter coat). Similarly, the ermine portrait of Queen Elizabeth the First shows her with her pet ferret, which has been decorated with painted-on heraldic ermine spots.

"The Ferreter's Tapestry" is a 15th-century tapestry from Burgundy, France, now part of the Burrell Collection housed in the Glasgow Museum and Art Galleries. It shows a group of peasants hunting rabbits with nets and white ferrets. This image was reproduced in *Renaissance Dress in Italy 1400–1500*, by Jacqueline Herald, Bell & Hyman.[a]

Gaston Phoebus' Book of the Hunt was written in approximately 1389 to explain how to hunt different kinds of animals, including how to use ferrets to hunt rabbits. Illustrations show how multicolored ferrets that were fitted with muzzles were used to chase rabbits out of their warrens and into waiting nets.

Import restrictions

- **Australia** – Ferrets cannot be imported into Australia. A report drafted in August 2000 seems to be the only effort made to date to change the situation.[64]
- **Canada** – Ferrets brought from anywhere except the US require a Permit to Import from the Canadian Food Inspection Agency Animal Health Office. Ferrets from the US require only a vaccination certificate signed by a veterinarian. Ferrets under three months old are not subject to any import restrictions.[65]
- **European Union** – As of July 2004, dogs, cats, and ferrets can travel freely within the European Union under the pet passport scheme. To cross a border within the EU, ferrets require at minimum an EU PETS passport and an identification microchip (though some countries will accept a tattoo instead). Vaccinations are required; most countries require a rabies vaccine, and some require a distemper vaccine and treatment for ticks and fleas 24 to 48 hours before entry. Ferrets occasionally need to be quarantined before entering the country. PETS travel information is available from any EU veterinarian or on government websites.
- **United Kingdom** – The UK accepts ferrets under the EU's PETS travel scheme. Ferrets must be microchipped, vaccinated against rabies, and documented. They must be treated for ticks and tapeworms 24 to 48 hours before entry. They must also arrive via an authorized route. Ferrets arriving from outside the EU may be subject to a six-month quarantine.[66]

See also

- Ferret-legging
- Sredni Vashtar

Notes

a. ISBN 0-391-02362-4

References

1. Harris & Yalden 2008, pp. 485–487
2. Bradley Hills Animal Hospital, Bethesda, Maryland, USA, on lifespan of Ferrets (https://web.archive.org/web/20060721081758/http://www.bradleyhills.com/ferrets/surgery/health/). Bradleyhills.com. Retrieved 2012-02-28.
3. "Ferrets: New Zealand animal pests" (https://web.archive.org/web/20140724222620/http://www.doc.govt.nz/conservation/threats-and-impacts/animal-pests/animal-pests-a-z/ferrets/). *Department of Conservation*. New Zealand Department of Conservation (DOC). 11 August 2006. Archived from the original (http://www.doc.govt.nz/conservation/threats-and-impacts/animal-pests/animal-pests-a-z/ferrets/) on 2014-07-24. Retrieved 25 July 2014.
4. ferret (http://www.merriam-webster.com/dictionary/ferret). Merriam-webster.com. Retrieved 2012-02-28.
5. Thomson, P. D. (1951). "A History of the Ferret". *Journal of the History of Medicine and Allied Sciences*. **vi** (Autumn): 471–480. doi:10.1093/jhmas/VI.Autumn.471 (https://doi.org/10.1093%2Fjhmas%2FVI.Autumn.471).
6. Schilling, Kim; Brown, Susan (2011). *Ferrets For Dummies* (https://books.google.com/books?id=B81UEcbj28gC&pg=PT125). John Wiley & Sons. pp. 125–. ISBN 978-1-118-05154-2.
7. Borgmann, Dmitri A. (1967). *Beyond Language: Adventures in Word and Thought*. New York: Charles Scribner's Sons. pp. 79–80, 146, 251–254. OCLC 655067975 (https://www.worldcat.org/oclc/655067975).
8. "All about ferrets" (http://njvma.org/all-about-ferrets/). New Jersey Veterinary Medical Association. Retrieved January 15, 2015.
9. "Domestic ferret" (http://www.elmwoodparkzoo.org/animal-domestic-ferret.php). Elmwood Park Zoo. Retrieved January 15, 2015.
10. Carroll, R. S., et al. "Coital stimuli controlling luteinizing hormone secretion and ovulation in the female ferret (https://academic.oup.com/biolreprod/article-pdf/32/4/925/10543529/biolreprod0925.pdf)." Biology of reproduction 32.4 (1985): 925-933.

11. "Ferrets" (http://www.pethealthinfo.org.uk/ferrets/). Pet Health Information. Retrieved 29 January 2010.
12. Robertson, John G. (1991). *Robertson's Words for a Modern Age: A Cross Reference of Latin and Greek Combining Elements* (https://books.google.com/books?id=M5hlO8sgpCgC). Senior Scribe Publications. p. 232. ISBN 978-0-9630919-1-8.
13. Brown, Susan, A. "Inherited behavior traits of the domesticated ferret" (http://www.weaselwords.com/page/ferret_art036.php). weaselwords.com. Retrieved 29 January 2010.
14. Clapperton BK, Minot EO, Crump DR (April 1988). "An Olfactory Recognition System in the Ferret Mustela furo L. (Carnivora: Mustelidae)". *Animal Behaviour*. **36** (2): 541–553. doi:10.1016/S0003-3472(88)80025-3 (https://doi.org/10.1016%2FS0003-3472%2888%2980025-3).
15. Zhang JX, Soini HA, Bruce KE, Wiesler D, Woodley SK, Baum MJ, Novotny MV (November 2005). "Putative Chemosignals of the Ferret (Mustela furo) Associated with Individual and Gender Recognition" (http://chemse.oxfordjournals.org/cgi/content/full/30/9/727#BIB12). *Chemical Senses*. **30** (9): 727–737. doi:10.1093/chemse/bji065 (https://doi.org/10.1093%2Fchemse%2Fbji065). PMID 16221798 (https://www.ncbi.nlm.nih.gov/pubmed/16221798). Online. Retrieved 2007-02-25.
16. Mitchell, Mark A.; Tully, Thomas N. (2009). *Manual of exotic pet practice* (https://books.google.com/books?id=JMTUKwzPEvwC&pg=PA372). Elsevier Health Sciences. p. 372. ISBN 978-1-4160-0119-5.
17. Schilling, Kim; Brown, Susan (2011). *Ferrets For Dummies* (https://books.google.com/books?id=B81UEcbj28gC&pg=PT302). John Wiley & Sons. p. 302. ISBN 978-1-118-05154-2.
18. Tynes, Valerie V. (2010). *Behavior of Exotic Pets*. Chichester, West Sussex: Blackwell Pub. p. 234. ISBN 978-0-8138-0078-3.
19. Williams, Bruce H. (January 1999) Controversy and Confusion in Interpretation of Ferret Clinical Pathology (https://web.archive.org/web/20080511003517/http://www.afip.org/consultation/vetpath/ferrets/Clin_Path/ClinPath.html), Armed Forces Institute of Pathology: "... the ferret, being by nature an obligate carnivore, has an extremely short digestive tract, and requires meals as often as every four to six hours."
20. Rethinking The Ferret Diet – Info about species-appropriate diets, and the negative effects of commercially prepared diets, written by a veterinarian (http://www.veterinarypartner.com/Content.plx?P=A&A=479&S=5). Veterinarypartner.com. Retrieved 2012-02-28.
21. McLeod, Lianne. Feeding Your Ferret (http://exoticpets.about.com/cs/ferrets/a/feedingferrets.htm). exoticpets.about.com
22. "Feeding Your Ferret," The Pet Wiki, Retrieved February 26, 2014 (http://www.thepetwiki.com/wiki/Feeding_Your_Ferret). Thepetwiki.com. Retrieved 2012-02-28.
23. "Feeding Ferrets whole rabbits ?" (http://www.thehuntinglife.com/forums/topic/191384-feeding-ferrets-whole-rabbits/). *The Hunting Life*. Retrieved 6 October 2012.
24. "Raw Diets" (https://web.archive.org/web/20131012052641/http://www.craftycreatures.com/forferretsonly/ask_angela/rawdiets.html). *For Ferrets Only*. Archived from the original (http://www.craftycreatures.com/forferretsonly/ask_angela/rawdiets.html) on 12 October 2013. Retrieved 6 October 2012.
25. "Gastrointestinal Disease in the Ferret" (http://www.lafebervet.com/small-mammal-medicine-2/ferret/diseases-of-the-ferret-gastrointestinal-tract/). Retrieved 24 April 2014.
26. "Frequently Asked Questions" (http://www.ferret.org/read/faq.html). *American Ferret Association*. Retrieved 24 April 2014.
27. Van Dahm, Mary. "An Owners Guide to Ferret Health Care" (http://weaselwords.com/ferret-articles/an-owners-guide-to-ferret-health-care/). *WeaselWords.com*. Retrieved 1 September 2013.
28. Drake, Samantha. "How to Take Care of a Ferret: Ferret care 101" (https://www.petmd.com/ferret/care/evr_ft_how-take-care-of-a-ferret-ferret-care-101). *www.petmd.com*. Retrieved 1 February 2019.
29. Sato JJ, Hosoda T, Wolsan M, Tsuchiya K, Yamamoto M, Suzuki H (February 2003). "Phylogenetic relationships and divergence times among mustelids (Mammalia: Carnivora) based on nucleotide sequences of the nuclear interphotoreceptor retinoid binding protein and mitochondrial cytochrome b genes". *Zoological Science*. **20** (2): 243–64. doi:10.2108/zsj.20.243 (https://doi.org/10.2108%2Fzsj.20.243). PMID 12655187 (https://www.ncbi.nlm.nih.gov/pubmed/12655187).

30. Church, Bob. "Ferret FAQ – Natural History" (http://www.ferretcentral.org/faq/history.html). ferretcentral.org. Retrieved 2007-08-25.
31. Matulich, Erika, PhD (2000). "Ferret Domesticity: A Primer" (http://www.cypresskeep.com/Ferretfiles/Domestic-FUSA.htm). *Ferrets USA*. Retrieved 2008-03-05.
32. Brown, Susan, DVM. "History of the Ferret" (http://www.veterinarypartner.com/Content.plx?P=A&A=496). Retrieved 2008-03-05.
33. "Feral Ferrets in New Zealand" (https://web.archive.org/web/20060905185101/http://www.dfg.ca.gov/hcpb/species/nuis_exo/ferret/ferret_issues_3.shtml). *California's Plants and Animals*. California Department of Fish and Game. Archived from the original (http://www.dfg.ca.gov/hcpb/species/nuis_exo/ferret/ferret_issues_3.shtml) on 2006-09-05. Retrieved 2006-09-12.
34. "Rabbit control" (https://web.archive.org/web/20010617215222/http://www.maf.govt.nz/MAFnet/articles-man/rbag/rbag0010.htm). *A Hundred Years of Rabbit Impacts, and Future Control Options*. New Zealand Ministry of Agriculture and Forestry (MAF) Rabbit Biocontrol Advisory Group. Archived from the original (http://www.maf.govt.nz/MAFnet/articles-man/rbag/rbag0010.htm) on June 17, 2001. Retrieved 2006-09-12.
35. Plinius the Elder, Natural History, 8 lxxxi 218 (http://penelope.uchicago.edu/Thayer/L/Roman/Texts/Pliny_the_Elder/8*.html#218) (in Latin)
36. Pliny the Elder (1601). "LV. Of Hares and Connies." (http://penelope.uchicago.edu/holland/pliny8.html). *Natural History, Book VIII*. Philemon Holland (trans). Retrieved 19 April 2011.
37. Mackay, Thomas, ed. (1891). *Plea for Liberty*. D. Appleton and Co.
38. "In Mystery, Ferret Thefts Sweep Southern England" (https://web.archive.org/web/20170321170935/https://www.wsj.com/news/articles/SB10001424052702304361604579290013495981126). *The Wall Street Journal*. Archived from the original (https://www.wsj.com/news/articles/SB10001424052702304361604579290013495981126) on 2017-03-21. Retrieved 2017-03-13.
39. Jurek, R. M. (1998). A review of national and California population estimates of pet ferrets (http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=39971). Calif. Dep. Fish and Game, Wildl. Manage. Div., Bird and Mammal Conservation Program Rep. 98-09. Sacramento, CA.
40. "Ferret Housing: The Humane Society of the United States" (http://www.humanesociety.org/animals/ferrets/tips/ferret_housing.html?credit=web_id139808899). *www.humanesociety.org*. Retrieved 2016-04-20.
41. Wildlife Act 1953 (http://www.legislation.govt.nz/act/public/1953/0031/latest/DLM278701.html#DLM278701) – Schedule 8
42. "Fish and Game Code Section 2118" (http://www.leginfo.ca.gov/cgi-bin/waisgate?WAISdocID=69408513066+1+0+0&WAISaction=retrieve). *California Codes*. State of California. Retrieved 2006-09-19. the Code states, in part: "animals of the families Viverridae and Mustelidae in the order Carnivora are restricted because such animals are undesirable and a menace to native wildlife, the agricultural interests of the state, or to the public health or safety."
43. "Section 671(c)(2)(K)(5): 'Family Mustelidae' " (https://web.archive.org/web/20130812174513/https://law.resource.org/pub/us/ccr/gov.ca.oal.title14.html). *California Code of Regulations, Title 14: Natural Resources, Division 1: "Fish And Game Commission – Department of Fish And Game", Subdivision 3: "General Regulations", Chapter 3: "Miscellaneous", Section 671: "Importation, Transportation and Possession of Live Restricted Animals"*. Archived from the original (https://law.resource.org/pub/us/ccr/gov.ca.oal.title14.html) on 2013-08-12. Retrieved 2006-09-19. Ferrets are not among the exceptions to the classification "Those species listed because they pose a threat to native wildlife, the agriculture interests of the state or to public health or safety are termed 'detrimental animals' " and are designated by the letter "D".
44. "News Release:Illegal Ferret Found in Kailua" (https://web.archive.org/web/20070929132134/http://www.hawaiiag.org/hdoa/newsrelease/00-21.htm). State of Hawaii Department of Agriculture. Archived from the original (http://www.hawaiiag.org/hdoa/newsrelease/00-21.htm) on 2007-09-29. Retrieved 2006-09-19.
45. Katie Redshoes. "Are Ferrets Legal in ...?" (http://home.netcom.com/~redshoes/ffztable.html). *List of Ferret-Free Zones*. Retrieved 2007-08-26.
46. "New York's Health Board Dashes the Hopes of Ferret Fans" (https://www.nytimes.com/2015/03/11/nyregion/sorry-ferrets-new-york-citys-ban-will-remain.html). *The New York Times*. Retrieved 11 March 2015.

47. Michael M. Grynbaum. "De Blasio's Latest Break With His Predecessors: Ending a Ban on Ferrets" (https://www.nytimes.com/2014/05/28/nyregion/de-blasios-latest-break-with-his-predecessors-ending-a-ban-on-ferrets.html). Retrieved 2014-05-27.
48. "R.I. Ferret Regulations" (https://web.archive.org/web/20060923191208/http://www.dem.ri.gov/pubs/regs/regs/fishwild/f_wferet.pdf) (PDF). State of Rhode Island and Providence Plantations Department of Environmental Management. June 27, 1997. Archived from the original (http://www.dem.ri.gov/pubs/regs/regs/fishwild/f_wferet.pdf) (PDF) on September 23, 2006. Retrieved 2007-07-05.
49. "Wild Bird and Game Bird Breeder Permit Application" (https://web.archive.org/web/20060805100847/http://dnr.state.il.us/admin/systems/06/game_app.pdf) (PDF). Illinois Department of Natural Resources. Archived from the original (http://dnr.state.il.us/admin/systems/06/game_app.pdf) (PDF) on 2006-08-05. Retrieved 2006-09-12.
50. "Wild Animals/Exotica" (https://web.archive.org/web/20160823014455/http://gadnrle.org/node/84). Georgia Department of Natural Resources. Archived from the original (http://gadnrle.org/node/84) on 23 August 2016. Retrieved 17 August 2016. "The exotic species listed below, except where otherwise noted, may not be held as pets in Georgia. [...] Carnivores (weasels, ferrets, foxes, cats, bears, wolves, etc.); all species. Note: European ferrets are legal as pets if neutered by 7 months old and vaccinated against rabies."
51. "Dallas" (https://web.archive.org/web/20060918001649/http://texasferret.org/lglprohibord.shtml). *Prohibited by Ordinance*. Ferret Lover's Club of Texas. 1996–2005. Archived from the original (http://www.texasferret.org/lglprohibord.shtml) on 2006-09-18. Retrieved 2006-09-19.
52. "Animal Services" (http://www.amlegal.com/nxt/gateway.dll/Texas/dallas/volumei/preface?f=templates$fn=default.htm$3.0$vid=amlegal:dallas_tx). *Dallas City Code, Chapter 7: "Animals"; Article VII: "Miscellaneous"*. American Legal Publishing Corporation. Retrieved 2006-09-19.
53. "Companion Animals" (https://web.archive.org/web/20090227182249/http://www.datcp.state.wi.us/ah/agriculture/animals/movement/companion_animals.jsp). Wisconsin Department of Agriculture, Trade, and Consumer Protection. Archived from the original (http://www.datcp.state.wi.us/ah/agriculture/animals/movement/companion_animals.jsp) on 2009-02-27. Retrieved 2008-11-13.
54. *Gallick v. Barto*, 828 F.Supp. 1168 (https://scholar.google.com/scholar_case?case=17736642397628316680&q=828+F.Supp.+1168&as_sdt=2,44) (M.D.Pa. 1993).
55. "Hokkaido Animal Welfare and Control Ordinance" (https://web.archive.org/web/20080309165724/http://www.pref.hokkaido.lg.jp/ks/skn/aigo/jyourei.htm). *Hokkaido Animal Welfare and Control Ordinance Chapter 2, Section 3*. Archived from the original (http://www.pref.hokkaido.lg.jp/ks/skn/aigo/jyourei.htm) on March 9, 2008. Retrieved 2009-04-10.
56. Matsuoka, Y.; Lamirande, E. W.; Subbarao, K. (2009). "The Ferret Model for Influenza". *Current Protocols in Microbiology*. *Current Protocols in Microbiology*. Chapter 15. pp. Unit 15G.2. doi:10.1002/9780471729259.mc15g02s13 (https://doi.org/10.1002%2F9780471729259.mc15g02s13). ISBN 978-0471729259. PMID 19412910 (https://www.ncbi.nlm.nih.gov/pubmed/19412910).
57. Maher JA, DeStefano J (2004). "The ferret: an animal model to study influenza virus". *Lab Animal*. **33** (9): 50–53. CiteSeerX 10.1.1.632.711 (https://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.632.711). doi:10.1038/laban1004-50 (https://doi.org/10.1038%2Flaban1004-50). PMID 15457202 (https://www.ncbi.nlm.nih.gov/pubmed/15457202).
58. Van Den Brand, J. M. A.; Stittelaar, K. J.; Van Amerongen, G.; Rimmelzwaan, G. F.; Simon, J.; De Wit, E.; Munster, V.; Bestebroer, T.; Fouchier, R. A. M.; Kuiken, T.; Osterhaus, A. D. M. E. (2010). "Severity of Pneumonia Due to New H1N1 Influenza Virus in Ferrets is Intermediate between That Due to Seasonal H1N1 Virus and Highly Pathogenic Avian Influenza H5N1 Virus". *Journal of Infectious Diseases*. **201** (7): 993–9. doi:10.1086/651132 (https://doi.org/10.1086%2F651132). PMID 20187747 (https://www.ncbi.nlm.nih.gov/pubmed/20187747).
59. Abanses, J. C.; Arima, S; Rubin, B. K. (2009). "Vicks Vapo *Rub* induces mucin secretion, decreases ciliary beat frequency, and increases tracheal mucus transport in the ferret trachea". *Chest*. **135** (1): 143–8. doi:10.1378/chest.08-0095 (https://doi.org/10.1378%2Fchest.08-0095). PMID 19136404 (https://www.ncbi.nlm.nih.gov/pubmed/19136404).
60. Crawford, Richard L.; Adams, Kristina M. (2006). "Information Resources on the Care and Welfare of Ferrets" (https://web.archive.org/web/20110213092535/http://www.nal.usda.gov/awic/pubs/Ferrets06/ferrets.htm). USDA Animal Welfare Information Center. Archived from the original (http://www.nal.usda.gov/awic/pubs/Ferrets06/ferrets.htm) on 2011-02-13.

61. "Ferret Racing | Countryman Fairs" (https://web.archive.org/web/20150423173347/http://www.countrymanfairs.co.uk/family-entertainment/ferret-racing). *www.countrymanfairs.co.uk*. Archived from the original (http://www.countrymanfairs.co.uk/family-entertainment/ferret-racing) on 2015-04-23. Retrieved 2015-04-19.
62. "Ferret Racing – Starescue – STA Ferret Rescue" (http://www.starescue.org.uk/racing/4579482855). *www.starescue.org.uk*. Retrieved 2015-04-19.
63. "American Ferret Association: Ferret Color and Pattern Standards" (http://www.ferret.org/events/colors/colorchart.html). Ferret.org. Retrieved 2008-11-30.
64. "Importation of Ferrets into Australia, Import Risk Analysis – Draft Report" (https://web.archive.org/web/20060910063747/http://www.daff.gov.au/corporate_docs/publications/pdf/market_access/biosecurity/animal/2000/00-036a.pdf) (PDF). Australian Quarantine and Inspection Service (AQIS). August 2000. Archived from the original (http://www.daff.gov.au/corporate_docs/publications/pdf/market_access/biosecurity/animal/2000/00-036a.pdf) (PDF) on 2006-09-10. Retrieved 2006-09-12.
65. "Importation of Foxes, Skunks, Raccoons and Ferrets" (https://web.archive.org/web/20090328022309/http://www.inspection.gc.ca/english/anima/heasan/import/foxrene.shtml). *Pet Imports*. Canadian Food Inspection Agency. 2006-03-20. Archived from the original (http://www.inspection.gc.ca/english/anima/heasan/import/foxrene.shtml) on 2009-03-28. Retrieved 2006-09-12.
66. "PETS: How to bring your ferret into or back into the UK under the Pet Travel Scheme (PETS)" (https://web.archive.org/web/20060901095759/http://www.defra.gov.uk/animalh/quarantine/pets/ferretpets.htm). *Animal health & welfare*. Department of Environment Food and Rural Affairs (defra) Crown copyright 2006. Archived from the original (http://www.defra.gov.uk/animalh/quarantine/pets/ferretpets.htm) on 2006-09-01. Retrieved 2006-09-12.

External links

- Chisholm, Hugh, ed. (1911). "Ferret" (https://en.wikisource.org/wiki/1911_Encyclop%C3%A6dia_Britannica/Ferret). *Encyclopædia Britannica* (11th ed.). Cambridge University Press.
- Isaacsen, Adolph (1886) *All about ferrets and rats (https://archive.org/details/allaboutferretsr00isaa)*
- View the ferret genome (http://www.ensembl.org/Mustela_putorius_furo/Info/Index/) on Ensembl
- Movies with ferrets in them as a character (https://fluffyplanet.com/movies-with-ferrets-in-them/)
- View the *musFur1* (https://genome.ucsc.edu/cgi-bin/hgTracks?db=musFur1) genome assembly in the UCSC Genome Browser.

Retrieved from "https://en.wikipedia.org/w/index.php?title=Ferret&oldid=896927384"

Received by email on Wednesday, July 10, 2019 at 9:58 AM as attachment 3 to petition 2019-018

Facts on Ferrets

The ferret is a domesticated animal whose ancestors are believed to be native European polecats (*Mustela putorius*). Inquisitive, smart, and playful, ferrets have become popular companion animals, but they require a special diet and care.[1] Often, after the novelty of an impulse purchase wears off, ferrets are abandoned to certain death in the wild or to severely crowded animal shelters.

Adoption

If you're willing to open your home to a ferret, first make sure that you don't live in an area that prohibits it: California and Hawaii both ban keeping ferrets as companion animals, and some local communities, such as New York City, also either restrict or ban the keeping of ferrets in homes.[2,3] Ask your local wildlife department, fish and game department, humane society, or veterinarian about the legality of keeping a ferret where you live and whether you will need to obtain a permit if you adopt one.

Please adopt from an animal shelter or rescue group. Search the Internet or ask your local humane society for a group near you. Never buy ferrets—or any other animal—from pet stores, which sell ferrets raised in disease-ridden, factory farm–like conditions. Please read our factsheet "Pet Shops: No Bargain for Animals (https://www.peta.org/issues/companion-animals-5/pet-shops-bargain-animals/)" for more information.

Ferrets can usually coexist peacefully and even amicably with cats and dogs. However ferrets should not be allowed free access to smaller pets such as birds or rodents. Supervision is a must, for the safety of the ferret and other animals. If you have young children, be sure to monitor their interaction with the ferret as closely as you would with a dog. Ferrets can and will bite in self-defense.

Ferret-Proofing

Maintaining a ferret-proof home is essential for the animal's safety and well-being.

Exercise caution, especially with the following tempting but potentially dangerous items in your home:

• Cabinets and drawers (Ferrets can open them.)
• Heaters (Ferrets might knock them over.)
• Furnace ducts (Ferrets can get inside them.)
• Recliners and sofa beds (Ferrets have been crushed in their levers and springs.)
• Anything spongy or springy, such as kitchen sponges, erasers, shoe insoles, foam earplugs, Silly Putty, foam rubber (including inside a cushion or mattress), Styrofoam, insulation, and rubber door stoppers (Swallowing pieces of these items will often result in an intestinal blockage.)

• Filled bathtubs, toilets, and water and paint buckets (Ferrets can drown in them.)
• Plastic bags (Ferrets can suffocate in them.)
• Holes behind refrigerators and other appliances with exposed wires, fans, and insulation (Ferrets love to chew on wires and eat insulation.)
• Dishwashers, refrigerators, washers and dryers (Ferrets can get trapped inside them.)
• Houseplants (Some are poisonous.)
• Box springs (Ferrets love to rip the cloth covering the underside of box springs and climb inside, where they may become trapped or crushed. To prevent this, attach wire mesh or a thin piece of wood to the underside of the box springs.)

Housing

Even if you plan to give your ferret the run of the house, it's best when you're not home to enclose him or her in a ferret-proof room or in a roomy, metal mesh cage—one that is at the very least 24 inches long, 24 inches deep, and 18 inches high, although larger enclosures are certainly preferable. If you have two or more ferrets living together, you will need a much larger cage and preferably multiple levels and sleeping areas. Whatever you decide, your ferret will appreciate ramps, tunnels made from dryer hose or black drainage pipe, a "bedroom" made out of an upside-down box with a cut-out doorway, and hammocks made from old jeans or shirts. Line the cage bottom with linoleum squares or cloth cage pads, and use old T-shirts and sweatshirts for bedding—never use cedar or pine shavings, which are toxic to small animals.

Don't let the temperature in their living quarters climb too high, and monitor the humidity. In the winter, when the heat is on and humidity can get too low, ferrets' skin can get dry and itchy, so use a humidifier. And if the humidity is allowed to get too high during the hot summer and the temperature rises above 85 degrees, ferrets can succumb to heatstroke. Keep in mind that ferrets' wild cousins live in underground burrows where the temperature is 55 degrees with 50 percent humidity.[4]

Litter Training

Ferrets can easily be trained to use a litterbox. They tend to choose their own toilet area in a corner, so start by putting a litterbox with paper pulp litter (NEVER clay or clumping litter) in that area. Gradually move the litterbox closer and closer to the area that you would like it to be in. Ferrets do love corners for their bathroom areas, so if you can put the litterbox in a corner, you will likely have greater success.

Diet

Ferrets are predators and strict carnivores and therefore require highly digestible, meat-based proteins. They cannot survive on vegetarian diets or most dog foods, as there is too much vegetable matter in those products, and too much carbohydrate in the diet can create health problems in ferrets.

If feeding dry kibble, be sure that the food contains at least 30 to 40 percent crude protein (of animal origin) and 15 to 20 percent fat. A thorough reading of the label is crucial—the first three ingredients should be meat-based.[5] Avoid processed treats marketed for ferrets, as they tend to be carbohydrate- or grain-based. Supplements should not be necessary if the optimal diet is being fed. For more details, please read "The Ferret Diet (https://beta.vin.com/doc/?id=4951366&pid=17256)" by Dr. Susan Brown.

Keeping Your Ferret Healthy

Ferrets require routine veterinary visits, just as dogs and cats do. If you live in an area that requires rabies shots for dogs and cats, then your ferret will need one too. Ferrets can also get heartworms, fleas, and canine distemper. Please consult your veterinarian about preventive measures. Do NOT use dips, sprays, or collars to combat fleas.

At 4 months, ferrets can be spayed or neutered. This procedure is necessary not only to prevent reproduction but also for the well-being of your animal companion. Neutering greatly decreases a male's body and urine odor once he matures and prevents him from urine-marking his territory in your home. Spaying also reduces a female's scent and prevents her from dying of severe anemia, which can develop in intact females who go into heat but do not breed.[6]

Ferrets kept mostly indoors will likely need nail-trimming every six to eight weeks. A veterinarian can show you the proper way to trim nails.

Exercise is important! You can simulate your ferret's need for burrowing and hunting with toys like large cardboard mailing tubes, dryer hoses, paper bags, PVC pipe, ping-pong balls, golf balls, and small cloth baby toys or feather cat toys that hang from springs. Please give your ferret time to play outside his or her cage for at least several hours every day.

Resources

American Ferret Association (http://www.ferret.org/index.html)
Associaton of Exotic Mammal Veterinarians (http://www.aemv.org/)

References

[1] J. Duda, "*Mustela putorius furo*," Animal Diversity Web (http://animaldiversity.org/accounts/Mustela_putorius_furo/), accessed 10 May 2018.
[2] Alex Distefano, "Culver City Woman Leads Fight to Make Ferrets Legal Pets in California," *LA Weekly* (http://www.laweekly.com/news/artists-out-chinese-capital-in-for-proposed-200-million-arts-district-center-9371354), 2 April 2018.
[3] Aaron Short, "NYC Fails to Overturn Ferret Ban," *NY Post* (https://nypost.com/2015/03/10/nyc-fails-to-overturn-ferret-ban/), 10 March 2015.
[4] Susan Brown, D.V.M., "Ferret Grooming," (https://www.vin.com/doc/?id=4951543&pid=17256) Small Mammal Health Series, 5 December 2011.
[5] Susan Brown, D.V.M., "The Ferret Diet," (https://beta.vin.com/doc/?id=4951366&pid=17256) Small Mammal Health Series, 14 March 2001.
[6] Natalie Antinoff, DVM, DABVP, "Anemia in ferrets: Clinical case challenges (Proceedings)" (http://veterinarycalendar.dvm360.com/anemia-ferrets-clinical-case-challenges-proceedings) CVC in Kansas City Proceedings, 1 August 2009.

URGENT ALERTS

(https://support.peta.org/page/11767/action/1)

Ask Walmart to Post Warning Signs Reminding Customers Not to Leave Dogs or Children in Hot Cars! (https://support.peta.org/page/11767/action/1)

(https://www.peta.org/action/action-alerts/dying-koi-fish-cumming-georgia/)

VICTORY

Update: 11 Koi Rescued From Abandoned Pond in Cumming! (https://www.peta.org/action/action-alerts/dying-koi-fish-cumming-georgia/)

(https://www.peta.org/action/action-alerts/brevard-productions-animal-giveaways-florida/)

Speak Out Against Animal Giveaways in Florida! (https://www.peta.org/action/action-alerts/brevard-productions-animal-giveaways-florida/)

(https://www.peta.org/action/action-alerts/open-admission-sheltering-policies-long-beach/)

Support Responsible, Open-Admission Sheltering Policies in Long Beach! (https://www.peta.org/action/action-alerts/open-admission-sheltering-policies-long-beach/)

(https://investigations.peta.org/iditarod-kennel-neglect/)

(https://www.peta.org/action/action-alerts/gratiot-county-animal-shelter/)

Groundbreaking Exposé Reveals Pain, Desolation, Abuse, and Systemic Neglect at Former Iditarod Champions' Kennels (https://investigations.peta.org/iditarod-kennel-neglect/)

URGENT: Speak Up for Animals in Gratiot County Today! (https://www.peta.org/action/action-alerts/gratiot-county-animal-shelter/)

(https://www.peta.org/about-peta/milestones/)

PETA's Milestones for Animals

VIEW NOW (HTTPS://WWW.PETA.ORG/ABOUT-PETA/MILESTONES/)

Also of Interest

The Honey Industry (https://www.peta.org/issues/animals-used-for-food/animals-used-food-factsheets/honey-factory-farmed-bees/)

Facts on Guinea Pigs (https://www.peta.org/issues/animal-companion-issues/animal-companion-factsheets/facts-guinea-pigs/)

Turkeys: Torture on the Holiday Table (https://www.peta.org/issues/animals-used-for-food/animals-used-food-factsheets/turkeys-factory-farmed-torture-holiday-table/)

Received by email on Friday, August 2, 2019 at 7:54 AM as a supporting letter to petition 2019-018

Cornman, Ari@FGC

From: [redacted]
Sent: Friday, August 2, 2019 7:54 AM
To: Cornman, Ari@FGC
Subject: RE: Ferret Petition

Hello Ari –

Thanks for the email. I understand this is probably a hassle for you. But it has turned out to be important.

When we got to a legislative body they tell us "if Fish and Game calls ferrets wild, they are the experts and that is good enough for us." At which point we are dead.

Rulemaking Authority (Required) - Reference to the statutory or constitutional authority of the Commission to take the action requested: **2118.** It is unlawful to import, transport, possess, or release alive into this state, except under a revocable, nontransferable permit as provided in this chapter and the regulations pertaining thereto, **any wild animal** of the following species: Mammals of the orders Primates, Edentata, Dermoptera, Monotremata, Pholidota, Tubulidentata, Proboscidea, Perissodactyla, Hyracoidea, Sirenia and Carnivora are restricted for the welfare of the animals, except animals of the families Viverridae and **Mustelidae** in the order Carnivora are restricted because such animals are undesirable and a menace to native wildlife, the agricultural interests of the state, or to the public health or safety.

We have gone through this petition process twice before. Our requests to have ferrets removed from the prohibited species list was rejected. Then we asked that Fish and Game issue permits and that was also denied.

But ferrets aren't wild animals. I understand, and I could be wrong, Fish and Game has the authority to regulate wild and exotic animals. While ferrets certainly are not wild, they could be considered exotic.

Perhaps the code should list domestic animals that are also prohibited.

Again, thank you for the time to understand this.

Pat Wright
LegalizeFerrets.org
(619) 303-0645 [redacted]

From: Cornman, Ari@FGC <Ari.Cornman@FGC.ca.gov>
Sent: Thursday, August 1, 2019 2:54 PM
To: [redacted]
Subject: Ferret Petition

Dear Pat Wright:
The California Fish and Game Commission has received your petition regarding ferrets. The petition is a bit unclear, so we are contacting you so we can understand exactly what it is you are requesting. We think you are asking that domestic

ferrets be added under family Mustelidae as an exception to the list of restricted species. Could you let us know if that is what you mean? Or if not, please explain your intent?
Thank You,
Ari

Ari Cornman, Wildlife Advisor
California Fish and Game Commission
1416 Ninth Street, Room 1320
Sacramento, CA 95814
Phone: 916-653-1595

STATE OF CALIFORNIA

FISH AND GAME COMMISSION
MEMORANDUM

DATE: October 10, 2016

TO: Members of Fish and Game Commission

FROM: Mike Yaun (Legal Counsel) and
Erin Chappell (Wildlife Advisor)

SUBJECT: Considerations for Ferret Legalization Associated with Petition #2016-008

Commission staff has drafted this memo to provide a detailed explanation for the staff recommendation regarding regulatory petition #2016-008 scheduled for Commission action under Agenda Item 32, Non-Marine Regulatory Petitions at its October 19-20, 2016 meeting.

Regulatory Overview

Petition #2016-008 requests the Commission amend Title 14 CCR Section 671(c)(2)(K) by removing any reference to domestic ferrets. Section 671 (Importation, Transportation and Possession of Live Restricted Animals) states that it is unlawful to import, transport, or possess live animals, restricted in subsection (c) except under a permit issued by the Department of Fish and Wildlife (DFW). The regulation specifically states in Section 671(b) that “the commission has determined the [animals listed in subsection (c)] are not normally domesticated in this state.” Currently, all species in the Family Mustelidae, including ferrets are listed in subsection (c). Within Section 671, ferrets are further designated as “detrimental animals” because they pose a threat to native wildlife, the agricultural interests of the State, or to public health and safety.

Applicable Fish and Game Code sections include:

- Section 2 - Unless the provisions or the context otherwise requires, the definitions in this chapter [Div .5, Ch 1 of the Fish and Game Code] govern the construction of this code and all regulations adopted under this code.
- Section 54 – "Mammal" means a wild or **feral mammal** or part of a wild or feral animal, but not a wild, feral, or undomesticated burro.
- Section 89.5 – "Wildlife" means and includes all **wild** animals, birds, plants, fish, amphibians, reptiles, and related ecological communities, including the habitat upon which the wildlife depends for its continued viability.
- Section 2116 – As used in this chapter [Div. 3, Ch. 2 of the Fish and Game Code], "wild animal" means any animal of the class … Mammalia (mammals …

which is **not normally domesticated in this state as determined by the commission.**

- Section 2118 – Prohibited importation or release into state of live wild animals of listed species, except under revocable, nontransferable permit.
- Section 2120(a) – The commission, in cooperation with the California Department of Food and Agriculture (CDFA), shall adopt regulations governing both (1) entry, importation, possession, transportation, keeping, confinement, or release of any and all wild animals imported pursuant to Chapter; and (2) the possession of all other wild animals. Regulations shall be designed to prevent damage to native wildlife and agriculture and to provide for welfare of the animal and safety of the public

Any change to the regulation would require coordination with CDFA and the proposed action would effectively eliminate the Commission's authority to regulate ferrets, with the exception of escaped individuals to the extent those individuals could be shown to have reverted to a wild state.

Supporting Documentation

Submitted with the petition were two pieces of supporting documentation: A report published by Dr. G.O. Graening (California State University, Sacramento) in 2010 and a CEQA checklist. The report, *Analysis of the Potential Impacts of Domesticated Ferrets Upon Wildlife, Agriculture, and Human Health in North America, with a Focus Upon California, Based Upon Literature Review and Survey of North American Governmental Agencies*, provides an accurate summarization of much of the existing information on domestic ferrets. The purpose of the report was to fully summarize the body of knowledge on the domesticated ferret (Mustela putorius furo) for potential impacts and an analysis to identify potentially significant issues so that Commission could proceed with the preparation of an Environmental Impact Report (EIR). The report identified three items that may need further analysis in an EIR: 1) the potential for the establishment of feral breeding populations; 2) potential impacts of ferrets on wildlife, either from an established population or from intentionally or inadvertently released ferrets; and 3) the potential economic impacts both beneficial and adverse of ferret legalization. The report also identified three items that may not need further analysis in an EIR: 1) the potential impacts to agriculture since there is no indication of impacts found in the literature or from a questionnaire of agricultural departments; 2) the potential impacts to human health from rabies, noting that impacts could be mitigated to a less than significant impact with required vaccination; and 3) the potential impacts to human safety from biting, noting that with effective mitigation measures this could be reduced to a less than significant impact.

Regarding potential impacts to wildlife populations, the report finds that while the establishment of feral colonies is improbable, there is a possibility that escaped ferrets might do significant damage to wildlife, such as ground-nesting birds or listed species, during a period up to a few weeks of survival (see Chapter 8, Section 2.2). It further notes that ongoing intentional releases or inadvertent escapes might replenish the population in the wild which could pose a continued hazard to wildlife. In addition, the report states that while pet-store ferrets do not possess the necessary traits to become invasive, pole-cat-ferret hybrids and polecats may possess the necessary traits. The report notes that both fertile ferrets and polecat-ferret hybrids are advertised for sale online. Therefore, some risk of them establishing a breeding population remains. How great a risk that poses to California's unique biodiversity remains unclear.

The CEQA Checklist provided identified biological resources, land use planning, and mandatory finding of significance as environmental factors potentially affected by the proposed change in regulation. For all three, the determination was that those impacts may be less than significant with mitigation. While the checklist did not identify any potentially significant impacts related to greenhouse gas emissions, the discussion section was not included in the materials provided. More broadly, the document does not include discussions about some of the conclusions found in the report - notably, the need to further analyze the potentially significant impacts to wildlife from the establishment of a feral breeding population of ferrets in an EIR or a discussion of the full breadth of the potential ramifications of legalization, such as the increased potential for polecat and polecat-ferret hybrids.

Even ignoring the omissions in the checklist outlined above, the findings require at a minimum, that the Commission develop a mitigated negative declaration before adopting the regulation. However, the Commission would not have authority to ensure that the proposed mitigation measures are implemented because the Commission does not have authority over domestic animals. Based on the inability to implement that mitigation, a full EIR is needed, even if founded on the existing checklist. It is important to note that if potentially significantly impacts are found in the EIR the adoption of that EIR would require a statement of overriding concern due to authority issues associated with mitigation.

Process for Preparing an EIR

As the Lead Agency under CEQA, the Commission would be responsible for preparing the EIR. Previously, the Commission directed that any new petitioner would need to fund the preparation of an environmental document, in this case an EIR, before considering any changes in the current regulation. Project proponent-funded environmental documents have been used by other agencies. For example, DFW has contract mechanism in place for this type of CEQA analysis. DFW adopted regulations (see Title 14 CCR sections 789.0-789.6) to allow for a special contract selection process. Through this process a project proponent contracts with DFW to pay for the contractor's work and DFW directs a previously-approved consultant to prepare the environmental document through the retainer contracts authorized in the regulations. The Commission would need to establish a similar process through regulations to pursue the development of a petitioner-funded EIR.

FGC Staff Recommendation

Staff recommends denying the petition. Given that the proposed action would effectively eliminate the Commission's authority to regulate ferrets, the potentially significant impacts to wildlife identified in the report, and the inability of the Commission to implement any identified mitigation measures, staff does not recommend removing ferrets from the list of restricted species at this time. However, if the Commission would like to move forward with the preparation of an EIR to further evaluate the potential impacts, staff recommends developing regulations to establish a contract selection process similar to the DFW regulations and proceed with a petitioner-funded EIR.

Finally, it is important to note that this issue is not specific to ferrets. Other species that are sometimes kept as domestic pets, such as hedgehogs and sugar gliders (species of possum), are also included in the list of restricted species. Any requests to remove them from the list would require similar considerations.

Cornman, Ari@FGC

From: Gary Ward
Sent: Tuesday, September 24, 2019 10:20 AM
To: FGC
Subject: Spring Bear Hunt

Hello, I recently heard of an upcoming proposal to establish a Spring Black Bear Hunt in California. I fully support this, as the bear population is exploding and fewer bears will increase the deer/elk fawn survival rate. Thank you.

Sent from AOL Mobile Mail
Get the new AOL app: mail.mobile.aol.com

Cornman, Ari@FGC

From: Megan Mitchell <californiaferrets@gmail.com>
Sent: Thursday, July 11, 2019 4:23 PM
To: FGC
Subject: Regarding New Petition Request for Ferrets

Dear President, Vice President, Commissioners and staff members:

I am the Executive Director of the United California Ferret Alliance, a new organization working within the system to decriminalize domestic ferrets. We've been made aware of a petition request you received earlier this week regarding ferrets that did not come from us or our affiliates. It comes from an independent organization. It requests that the Fish and Game Commission no longer refer to ferrets as wild but domesticated. As the petitioner pointed out, many well known organizations do use this term when referring to this animal. However we do not feel it is necessary to attract a legislator.

We know that over the years there have been numerous petitions for policy change in front of the Commission regarding ferrets. We respect the amount of time and resources that have to be used to address items that make it onto the Commission's agenda.

Recently, I had the pleasure of meeting with a few of your staff members and we extensively discussed policy and procedures that affect the status of ferrets in California. After meeting with your staff I feel I have a new understanding of some of the constraints that fall not only on the Commission but the hard working staff members.

We are working tirelessly to build support for a bill to address removing the criminal aspect of ferret ownership. We're hoping to work with the Department of Wildlife to find agreeable regulations so that responsible ferret owners no longer have to worry about their pets being confiscated and euthanized by the state. We've even established communication with the Sierra Club and they are interested in our approach to the issue.

We want to reassure the Commission that no matter if the new petition request makes it on the agenda or not, the United California Ferret Alliance and its affiliates, will not negatively or publicly criticize your agency. We hope to be able to continue to work with your staff to find a policy that can help us succeed and keep ferrets off your agenda for many years to come.

Thank you for your time.

Sincerely,
Megan Mitchell

--
Executive Director, United California Ferret Alliance
"An umbrella organization bringing together like-minded ferret clubs & enthusiast to decriminalize domestic ferrets in California."

(310) 425-3851
P.O. Box 47507
Los Angeles, CA 90047
#CaliforniaFerrets

Cornman, Ari@FGC

From: W.F.U. & W.F.I.C. <WFU@telfort.nl>
Sent: Monday, September 16, 2019 10:33 AM
To: FGC
Subject: Domestic ferrets are not wild animals

We of the World Ferret Union and World Ferret Information Centre would like to inform you about the ferret which is a domestic animal and isn't legal in your state. Other states in the United States of America have dealt with the issue regarding ferrets and legalized them. Only Hawaii, California and a part of New York don't allow keeping ferrets as pets. But only California showing pure unwillingness and your state doesn't have a reasonable argument to ban them.

Ferrets have always been domestic animals. Tracing their relationship to humans as far back as possible - that is: 200 BC - proves so. They cannot survive in the wild and are totally dependent on their caretakers. All arguments are well known to the insiders of this matter.

Please read information on our Website about ferrets on the page http://www.wfu-wfic.org/ferret.html

Sincerely,

World Ferret Union and World Ferret Information Centre

http://www.wfu-wfic.org/

Cornman, Ari@FGC

From: Karl L. Swartz [redacted]
Sent: Sunday, September 8, 2019 10:10 PM
To: FGC
Subject: Petition 2019-018

Dear commissioners,

Please support petition 2019-018. Domestic ferrets (*Mustela putorius furo*, not to be confused with *Mustela nigripes*, the black-footed ferret) are no more wild animals than dogs (*Canis familiaris* or *Canis lupus familiaris*, depending upon which taxonomy you follow) or cats (*Felis catus*). Ferrets were domesticated approximately 2,500 years ago. Several papers and articles on or mentioning the domestication history of ferrets including comparisons to dogs:

- Man’s Underground Best Friend: Domestic Ferrets, Unlike the Wild Forms, Show Evidence of Dog-Like Social-Cognitive Skills (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0043267)
- History of the Ferret (https://weaselwords.com/ferret-articles/history-of-the-ferret/)
- Ferrets: Man's Other Best Friend (https://blogs.scientificamerican.com/thoughtful-animal/ferrets-mans-other-best-friend/)

--
Karl L. Swartz
Mountain View, California

Cornman, Ari@FGC

From: Kathleen Dodson [redacted]
Sent: Monday, September 9, 2019 2:50 PM
To: FGC
Subject: Petition 2019-018

Please support petition 2019-018. Domestic ferrets aren't wild animals.

Please note I have had ferrets for 25 years and in all of those years I have only ever been able to purchase 1 ferret that was not fixed before I brought it home. Ferrets who are decented and fixed by the pet industry do not survive on their own. They have been domesticated for so long that they do not know how to survive if they escape. Once a ferret reaches maturity they do not willingly change their food source and will starve. I have rescued ferrets for years, several which were dying from starvation because the owners did not understand the proper way to change their diet. ferrets are affectionate loving animals that can be taught appropriate behavior like any dog or cat. Ferrets have been domesticated for thounsands of years. The ferrets we call pets are not the same animals as they were years ago. It is very odd that California calls our ferrets wild. If that were they case, then why do most states allow them to be pets?

Kathleen D. Dodson, M.Ed., CRC
Sequim, WA

Cornman, Ari@FGC

From: Josh Hall [redacted]
Sent: Friday, September 6, 2019 3:23 PM
To: FGC
Subject: Petition 2019-18

I'd like to voice my support of this petition. The domesticated ferret wouldn't be called the DOMESTICATED ferret, if it was a wild animal.

The Domesticated ferret is a domesticated version of the European polecat much like our dogs are often domesticated versions of wolves.

To make this false categorization of an animal that is clearly domesticated basically calls in to question the credibility of the fish and game commission. How can an organization that's supposed to be experts on animals be considered credible when this type of misinformation is allowed to be considered fact?

How many ferrets would have to die to satisfy some sort of scientific evidence that they cannot survive in California as escapees? Is that what we really want to strive for, or can we agree with the REST OF THE SCIENTIFIC COMMUNITY and properly categorize them as domesticated pets?

Ferrets are not polecats just as your dog is not a wolf. Hence ferrets are not WILD animals, they're domesticated.

If the domesticated ferret is so invasive, why hasn't there been any reports of it happening in any of the 48 states where they're completely legal? Do they know something we don't? Clearly they do. It's that they're not a threat to the environment.

Citing the Sierra club as a concern for being sued? They don't even think cats and dogs should be pets, so let them make their mistakes and die on that hill alone. The Fish and Game commission shouldn't be lending itself to political agendas such as that.

--
Regards,
Josh Hall
"I like to know what I'm talking about, before I open my mouth." - President Barack Obama
"Don't be evil." - Google

Cornman, Ari@FGC

From: Donna Ferreira
Sent: Monday, September 23, 2019 10:39 AM
To: FGC
Subject: Petition 2019-018

Please support petition 2019-018. Domestic ferrets aren't wild animals.

Dear Members of the Fish and Game Commission,

As a former ferret owner I would kindly ask that you revise your language and Not refer to ferrets as wild animals, they are Not. They are as domestic as a dog or cat. And I have owned both for over 50 yrs. These cute, comical, intelligent, and lovable pets depend on us for survival. They would be lucky to survive in the wild more than a day. They are not born or raised in the wild.

The bond they have with humans can be as compassionate (towards us) as any domestic pet. It is definitely a relationship like no other. If you read stories about ferrets and their owners you would have to agree. My ferret would lay at my feet every day as I put on my make-up to go to work. This was our routine and she knew I would be leaving soon. This is just one example. My ferret,, Keela, was in No Way a wild animal. I implore you to read more stories and educate yourselves with Ferrets Anonymous literature and the years of research they have done.

Thank you for your consideration.

Sincerely,
Donna Ferreira

Cornman, Ari@FGC

From: Mishele Barker [redacted]
Sent: Wednesday, September 25, 2019 3:49 PM
To: FGC
Subject: “Petition 2019-18”

Please Support Petition 2019-018, domestic ferrets are not wild animals!

They are legal in every continental state and there are no instances of domestic ferrets forming feral colonies. The majority of ferrets are spayed/neutered before being sold, so they cannot reproduce. Even if an unaltered ferret was to escape, the odds of it locating another unaltered ferret to mate with is astronomical. And the likelihood that it will figure out how to find food and water (having been raised on kibble) is practically nil. Not to mention, **If female ferrets** go into heat and do not **mate** or are not spayed, **they** can develop **a** severe, and even life threatening anemia. This is because estrogen can cause **the** bone marrow to stop producing red blood cells.

Continuing this absurd ban on ferrets is rediculous. They impact the environment much, much less than any other domestic animal, including dogs and cats.

Michelle Barker

[Sent from Yahoo Mail on Android]

Cornman, Ari@FGC

From: Monica Hail [redacted]
Sent: Tuesday, September 17, 2019 10:31 PM
To: FGC
Subject: Petition 2019-18

Hello to whom it concerns,

Ferrets need to welcomed in California. Domesticated Ferrets are pets not wild animals. I have always wanted a ferret since I was a child, but sadly I have been born and raised in good old California and unfortunately they are banned here. As a teenager I got curious and looked into why they are banned here in California. Since I think there are other creatures people are allowed to have here which are far worse then a ferret ever was.

When I looked into it I had found out that they are banned because they "can" escape and cause damage to the ecosystem here. Well, their are far worst creatures that are not banned here that are far worst then a ferret ever thought of being. Snakes, cats, aquarium fish, lizards... just too name a few. I also remember something about they can escape and breed with their wild cousins the black footed ferret, who since has gone extinct here in California.

They are fun pets that give their owners joy every day with their funny antics. Do you know that they have what's called a war dance? If you don't you should go and look up a few of YouTube videos. Its the funniest thing you would ever see.

Californians are missing a pet who is a true pleasure to own. They are curious like a cat and silly like dogs. They can have shots just like dogs so to not carry "rabies" as some say. They can be spayed and neutered so to not breed. Most human ferret parents have their fixed as they got a sac back there that stinks (think of a skunk). The only way to get rid of the smell is to have it fixed, so most are fixed by the breeders before they ever even leave their mothers. Well what I trying to say is ease let California enjoy these amazing little creatures. This law is as old as a dinosaur and needs to changed, let us enjoy this amazing pets!!!!

Thank you,
Monica Hail

[redacted]

Cornman, Ari@FGC

From: Rene Gandolfi [redacted]
Sent: Monday, September 23, 2019 10:51 AM
To: FGC
Subject: Petition 2019-018

Please support petition 2019-018. Domestic ferrets aren't wild animals.

An important function of any governmental agency that has any involvement with science is to apply scientific knowledge in its decision making processes.

Biology is a science and the domestication of animals is governed by scientific principles.

Ferrets are a domesticated species. Legislation or regulation does not change the underlying science of that classification any more than would a regulation stating that the sun in California rises in the west or that the Earth is the center of the universe and all the stars and planets revolve around it

Rene Charles Gandolfi, DVM, Dipl. ABVP, CVA

Cornman, Ari@FGC

From: Juliana Lenny [redacted]
Sent: Sunday, September 8, 2019 6:51 PM
To: FGC
Subject: Petition 2019-018

Please support petition 2019-018. Domestic ferrets aren't wild animals.

CALIFORNIA FISH AND GAME COMMISSION
REQUESTS FOR NON-REGULATORY ACTION 2019 - SCHEDULED FOR ACTION
Revised 09-30-2019

FGC - California Fish and Game Commission **DFW** - California Department of Fish and Wildlife **WRC** - Wildlife Resources Committee **MRC** - Marine Resources Committee

Grant: FGC is *willing to consider* the request **Deny:** FGC is *not willing to consider* the request **Refer:** FGC *needs more information* before deciding whether to grant or deny the request

Green cells: Referrals to DFW for more information
Lavender cells: Accepted; no further action needed
Blue cells: Referrals to FGC staff or committee for more information
Yellow cells: Current action items

Date Received	Name of Petitioner	Request category (Marine or Wildlife)	Subject of Request	Short Description	FGC Decision	Staff / DFW Recommendations
7/1/2019	Chris Clardy City of Colfax	Wildlife	Petition to list foothill yellow-legged frog under the California Endangered Species Act (CESA)	Request for FGC to find that the petitioned action to list foothill yellow-legged frog under CESA is not warranted and the petition process be ended.	**Receipt: 8/7-8/2019** **Action: 10/9-10/2019**	The request is contrary to CESA statute. No futher action recommended.
7/15/2019	Tim Dummer	Wildlife	Public access for fishing in waters impounded by dams	Request for FGC to take legal action against the San Francisco Public Utilities Commission for violations of several statutes, including Fish and Game Code Section 5943 concerning public access for fishing in waters impounded by dams.	**Receipt: 8/7-8/2019** **Action: 10/9-10/2019**	FGC does not enforce violations of the Fish and Game Code. No further action recommended.
7/16/2019	Donald Baldwin	Wildlife	Security of personal and confidential information	Request to secure access to personal and confidential information housed in DFW's Automated License Data System (ALDS).	**Receipt: 8/7-8/2019** **Action: 10/9-10/2019**	DFW controls the access to and maintenance of ALDS content, not FGC; DFW has been notified of the request and taken appropriate action. No further action recommended.
7/25/2019	Tom and Patricia Randolph	Wildlife	Use of seasonal dam and swimming hole at Trinity Alps Resort	(1) Request to approve a permit for Trinity Alps Resort's continued use of a seasonal dam and swimming hole while the status of foothill yellow-legged frog under CESA is being determined, and (2) a request to consult with the California Attorney General about the legality of CESA proceedings and potential liability to FGC and DFW of denying permits during those proceedings.	**Receipt: 8/7-8/2019** **Action: 10/9-10/2019**	FGC received several similar letters on this issue; staff has responded with letters to commenters clarifying that the permits in question are approved by DFW, and that FGC does not have a role. No further action recommended.
8/7/2019	James Stone NorCal Guides and Sportsmen's Association	Wildlife	Guide licensing application	Request that DFW revise the application form for guide licensing, and require that necessary documentation to be a guide be provided by applicants.	**Receipt: 8/7-8/2019** **Action: 10/9-10/2019**	Requests for form revision, documenation requirements, or a change in guide qualifications would require regulatory changes and should be submitted on form FGC 1. Other concerns should be directed to DFW. The requestor has been notified; no further action recommended.
8/7/2019 8/7/2019	Danny Offer, Platinum Advisors, on behalf of Curt Hagman, Chair, San County Board of Supervisors.and Steve Wallauch, on behalf of San Bernardino County Board of Supervisors	Wildlife	Petition to list San Bernardino kangaroo rat under the California Endangered Species Act (CESA)	Request for FGC to either reject DFW's evaluation of the petition to list San Bernardino kangaroo rat under CESA and reopen the public comment period on the petition, or continue consideration of the petition to a meeting subsequent to the scheduled August 7-8, 2019 FGC meeting.	**Receipt: 8/7-8/2019** **Action: 10/9-10/2019**	FGC determined in August 2019 that listing the San Bernadino kangaroo rat under CESA may be warranted. Comments may be submitted during the CESA comment period. No further action recommended.

From: Laoyan, Gem@Wildlife <Gem.Laoyan@wildlife.ca.gov>
Sent: Wednesday, August 7, 2019 4:42 PM
To: Bonham, Chuck@Wildlife <Chuck.Bonham@wildlife.ca.gov>; Miller-Henson, Melissa@FGC <Melissa.Miller-Henson@fgc.ca.gov>
Cc: Lehr, Stafford@Wildlife <Stafford.Lehr@wildlife.ca.gov>; Thesell, Harold(David)@FGC <Harold.Thesell@FGC.ca.gov>; Ortiz, Jan@Wildlife <Jan.Ortiz@wildlife.ca.gov>
Subject: FW: Letter from San Bernardino County RE: Petition to List the San Bernardino Kangaroo Rat

Good afternoon, please see below an email and attachments from Platinum Advisors regarding a petition to list the San Bernardino Kangaroo Rat. Mr. Thesell will please distribute copies to the Commissioners as well, thank you for your assistance. The letter is from San Bernardino County Board of Supervisor, Curt Hagman.

Gem Laoyan, Administrative Assistant to
Valerie Termini, Chief Deputy Director
CA Department of Fish & Wildlife
P.O. Box 944209
Sacramento, CA 94244-2090
(916) 653-7667

From: Danny Offer <dpo@platinumadvisors.com>
Sent: Wednesday, August 7, 2019 4:26 PM

To: Laoyan, Gem@Wildlife <Gem.Laoyan@wildlife.ca.gov>
Subject: Letter from San Bernardino County RE: Petition to List the San Bernardino Kangaroo Rat

Hi Gem –

I see that Jan is out this week.

Are you able to circulate the attached letters from San Bernardino County to:

Director Bonham
VP Hostler-Carmesian
President Sklar
Commissioner Burns
Commissioner Silva
Commissioner Murray

Thank you in advance!

Danny Offer, Lobbyist
Sacramento | 916.443.8891
PLATINUM | ADVISORS
PlatinumAdvisors.com | LinkedIn | Facebook

385 North Arrowhead Avenue, 5th Floor, San Bernardino, CA 92415-0120 | Phone: 909.387.4821 Fax: 909.387.5430
www.SBCounty.gov

SAN BERNARDINO COUNTY

County Administrative Office
Governmental & Legislative Affairs

Josh Candelaria
Director

August 5, 2019

Mr. Eric Sklar
President
California Fish and Game Commission
1416 Ninth Street, Suite 1320
Sacramento, CA 95814

Re: Petition to List the San Bernardino Kangaroo Rat

Dear President Sklar:

The County of San Bernardino wishes to express concern about the petition to list the San Bernardino kangaroo rat (SBKR) under the California Endangered Species Act.

It appears the Department of Fish and Wildlife may have only partially met its statutory requirement for noticing by publishing a notice of receipt of the petition in the California Regulatory Notice Register. However, the California Fish and Game Code §2073.3(b) requires that "(t)he Commission shall notify interested persons pursuant to Section 2078, by mail of the notices prepared pursuant to subsection (a), and shall mail a copy of the notice to those persons."

The County was unaware of the petition until recently. While Fish and Game Code Section 2078 requires interested persons to notify the Commission in writing, it would seem a potential action of this importance and consequence for our County would have merited a more robust notification and outreach effort.

Further, the County of San Bernardino is pursuing a Regional Conservation Investment Strategy, which would provide additional protection in addition to SBKR's current protection of more than two decades under the Federal Endangered Species Act, which has included ongoing mitigation and recovery efforts. There is concern that the County, as provider of public safety infrastructure, and also as the permitting jurisdiction for any number of projects that provide housing and economic development for our residents, would face additional complex and duplicative regulatory requirements, which will provide little, or no, benefit to the SBKR.

Therefore, the County of San Bernardino respectfully requests that the Commission either reject CDFW staff's evaluation and reopen the public comment period on the petition to allow adequate analysis and comment, or that you at least continue your consideration of the petition until a meeting subsequent to your scheduled August 7-8, 2019 meeting.

If you have any questions regarding the County's position, please do not hesitate to contact Josh Candelaria, Director of Governmental and Legislative Affairs at (909) 387-4821 or jcandelaria@sbcounty.gov.

Sincerely,

Curt Hagman

Fourth District Supervisor
Chairman, San Bernardino County Board of Supervisors

cc: Commission Vice President Jacque Hostler-Carmesin
Commissioner Russell Burns
Commissioner Peter S. Silva
Commissioner Samantha Murray
CDFW Director Charlton Bonham

STAFF SUMMARY FOR AUGUST 22-23, 2018

17. STRATEGIC PLANNING

Today's Item **Information** ☐ **Action** ☒

This is a standing agenda item for 2018-19 FGC meetings as FGC develops a new strategic plan. Today's discussion and potential action will take place in a workshop format.

Summary of Previous/Future Actions

- First FGC strategic planning meeting — Feb 22, 2018; Sacramento
- Discussion held over to Jun meeting — Apr 18-19, 2018; Ventura
- Discussion of mission, vision, core values — Jun 20-21, 2018; Sacramento
- **Today's discussion of potential mission, vision and core values** — **Aug 22-23, 2018; Fortuna**
- Consider adopting mission, vision and core values — Oct 17-18, 2018; Fresno

Background

FGC created its current strategic plan in 1998, which includes a mission statement and a vision statement. Over the ensuing 20 years, much has changed, not the least of which is a commission with broader authorities and a more ecosystem-based approach to addressing fish and wildlife issues. With the upcoming 150-year anniversary of FGC, the time is right to reassess its mission and vision statements, and to potentially adopt a set of core values or a core values statement.

At its Feb 22, 2018 strategic planning kickoff meeting, FGC discussed the overall goals of a new strategic plan and the type of strategic planning process in which to engage. FGC determined that it is seeking a streamlined planning process, given that there is significant information and input on which to build a new strategic plan, including the 2012 "California Fish and Wildlife Strategic Vision: Recommendations for Enhancing the State's Fish and Wildlife Management Agencies."

Today's meeting marks the second focused on potential changes to FGC's mission and vision (Exhibit 6) and a potential statement of core values. As requested during the Jun 2018 FGC meeting, staff has prepared a document that provides samples of mission and vision statements for other fish and game commissions in the United States as well as the U.S. Fish and Wildlife Service; in some cases, there is not a separate fish and game commission from the state's wildlife management agency (Exhibit 1).

After the Jun 2018 discussion, some commissioners were able to provide feedback on the current mission and vision statements, as well as potential core values (Exhibit 2) to help facilitate additional discussion during today's workshop. In addition, to complement the work of FGC, staff has reviewed and discussed potential changes to the mission and vision statements and identified potential core values (exhibits 3-5). These exhibits are meant to help facilitate an engaging discussion with commissioners to develop thoughtful and forward-thinking strategic planning documents.

Today's discussion is being held in a workshop format so that commissioners, staff and stakeholders can have a direct dialogue about the ideas generated to date, to develop additional ideas, and provide guidance to staff on potential changes to the mission and vision statements and on potential core values. FGC is scheduled to consider adopting the mission, vision and core values at its Oct 17-18, 2018 meeting.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

1. Samples of mission and vision statements and core values from other states, dated Aug 10, 2018
2. Input from commissioners on potential mission, vision and core values, dated Aug 13, 2018
3. Input from FGC staff on FGC vision, dated Aug 14, 2018
4. Input from FGC staff on FCG mission, dated Aug 14, 2018
5. Input from FGC staff on FGC potential core values, dated Aug 14, 2018
6. Current FGC mission and vision statements, adopted in 1998

Motion/Direction

Provide staff with direction on potential changes to the mission and vision statements, as well as core values.

California Fish and Game Commission

Commission Mission, Vision and Core Values

Adopted December 13, 2018

Mission

The mission of the California Fish and Game Commission, in partnership with the California Department of Fish and Wildlife, is to provide leadership for transparent and open dialogue where information, ideas and facts are easily available, understood and discussed to ensure that California will have abundant, healthy, and diverse fish and wildlife that thrive within dynamic ecosystems, managed with public confidence and participation, through actions that are thoughtful, bold, and visionary in an ever-changing environment.

We recognize our responsibility to hold California's fish and wildlife and their habitats in the public trust, as well as their cultural and intrinsic value, and therefore work collaboratively with other federal, tribal, state and local government agencies, non-governmental organizations and the people of California to establish scientifically-sound policies and regulations to protect, enhance and restore California's native fish and wildlife in their natural habitats, and to secure a rich and sustainable outdoor heritage for all generations to experience and enjoy through both consumptive and non-consumptive activities.

Vision

The vision of the California Fish and Game Commission is a healthy and biodiverse, natural California in which an array of native fish and wildlife thrive within dynamic ecosystems and inspire human interaction and enjoyment.

Core Values

Integrity

We hold ourselves to the highest ethical and professional standards, pledging to transparently fulfill our duties and deliver on our commitments to protect and hold California's fish and wildlife and their ecosystems in the public trust, to ensure consistency of expectations and outcomes. We ensure that our choice or order of decision-making does not arbitrarily prioritize one interest group over others. We hold ourselves accountable to act in accordance with our values and code of ethics, even when it is difficult. Our actions reflect honesty, truthfulness, respect and accuracy.

Transparency

We recognize the important and wide-ranging impacts the Commission's decisions have on California's wildlife, wildlife habitat and residents, and that these decisions should be made based on a variety of inputs in an open, inclusive and public process that solicits a diverse set of perspectives. We strive to communicate with our partners, our stakeholders and the public responsively and openly about how and why decisions are made. We use adaptive processes and consistently gather as much information as possible to ensure the Commission is best informed for thoughtful decision-making, while acknowledging that decisions are most often made with incomplete information.

Innovation

We respond to the ever-changing natural and human environments by evaluating the efficiency and effectiveness of our decisions and processes, identifying new ideas that challenge conventional wisdom and historical biases, and seeking opportunities for innovation. We recognize that innovation always involves some element of risk, and that creative problem-solving and implementing forward-thinking solutions where value is added is key to meeting the constantly evolving needs of our stakeholders and California's fish and wildlife. We take time to frame challenges, adapt, and execute new and useful ideas, including applying advances in sound science, evolving concepts of wildlife management, and public values toward wildlife in new and bold ways. We encourage novelty, creativity and flexibility as we proactively meet challenges and problem-solve.

Collaboration

We value collaboration, including teamwork and partnerships, in problem-solving and in developing policies and regulations. Teamwork is actively fostered and is one of the main ways we function. Collaborative efforts extend beyond the Commission and its staff to empower a diversity of stakeholders, other federal, tribal, state and local agencies, non-governmental organizations, and the people of California to participate in our problem-solving and decision-making processes and, where appropriate, engage in working groups that are inclusive and transparent.

We pursue productive and considerate partnerships, rather than relationships solely based on a formal legal agreement, and celebrate one another's successes as we take them to the next level together. A partnership is a mutually beneficial arrangement that leverages resources to achieve shared goals between and among the partners, based on mutual respect, open-mindedness, trust, and genuine appreciation of one another's contribution. Our primary partner is our sister agency, the California Department of Fish and Wildlife.

Excellence

We pursue quality, proactively assessing performance and striving to continuously improve the delivery of fair and accessible services, work products and decisions, as well as the efficiency and cost-effectiveness with which these are delivered. We are committed to being and delivering the best, and are diligent about creating better ways of doing what we do. We take pride in our efforts and what we make possible. We approach every challenge with an expectation and determination to succeed.

Stewardship

We hold the state's wildlife and their habitats and ecosystems in trust for the public, respecting that they have intrinsic value and are essential to the well-being of all California residents. We give attention to the environmental and human stressors, including climate change, development and other threats, that affect the resilience and health of our wildlife and their habitats and ecosystems. We use credible science, evolving concepts of wildlife management, and public values toward wildlife to evaluate programs, policies and regulations that will help achieve our stewardship goals. We recognize the dynamic nature of and stay abreast of changes in science, and that it should include the evaluation principles of relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation and peer review of information as appropriate.

STAFF SUMMARY FOR AUGUST 7-8, 2019

15. STRATEGIC PLANNING

Today's Item **Information** ☒ **Action** ☐

This is a standing agenda item for 2018-19 FGC meetings as FGC develops a new strategic plan. Today's discussion and potential action will take place in a workshop format, to receive input on a series of strategic planning questions that will help guide development of draft goals.

Summary of Previous/Future Actions

• First FGC strategic planning meeting	Feb 22, 2018; Sacramento
• Discussion of draft mission, vision, core values	Jun, Aug, Oct 2018; various
• Adopted mission, vision, and core values	Dec 12-13, 2018; Oceanside
• Received updates	Feb, Apr, Jun 2019; various
• **Today's input on seven key questions**	**Aug 7-8, 2019; Sacramento**

Background

In anticipation of FGC's upcoming 150-year anniversary in 2020, a strategic planning process was initiated in early 2018 (see Exhibit 1 for background). In the first of a three-phase process, FGC reassessed its mission and vision, and developed a set of core values, in concert with staff and stakeholders. Adopted in Dec 2018, the revised mission, vision, and new core values (Exhibit 2) are serving to guide a forward-thinking update to the strategic plan.

In Jun 2019, staff reported that the second phase of the planning process was ramping up, to consist primarily of data gathering and synthesis with staff, stakeholders and commissioners. Staff has been reviewing strategic plans developed by other wildlife-focused organizations, assessing surveys conducted through other strategic planning processes, developing a series of questions for an online survey as well as in-person and phone interviews, and creating lists of participants for the survey and interviews. The information gathered during this phase will be analyzed and used to help guide development of draft goals for FGC consideration.

This agenda item will be held in a workshop format, where commissioners can receive input from members of the public on seven key questions:

1. Briefly describe, in a few words or sentences, how you and/or your organization perceive FGC.
2. What do you believe are FGC's three greatest strengths?
3. What are FGC's three areas in greatest need of improvement?
4. What are the three greatest opportunities available to FGC as it moves forward over the next five years?
5. What are the three greatest obstacles FGC is facing in the next five years?
6. In the next five years, what goals do you believe should be the highest priority for FGC?

7. What is your level of trust that FGC leaders are responsible stewards of the resources under their authority?

This item will begin at 3:00 p.m. or 30 minutes after the last agenda item heard today, whichever is later.

Significant Public Comments (N/A)

Recommendation

Exhibits

1. Staff summary from Agenda Item 23, Strategic Planning, June 12-13, 2019 (for background only)
2. FGC mission, vision and core values, adopted Dec 13, 2018

Motion/Direction (N/A)

CDFW and Partners Remove Illegal Cannabis Grows Near Sensitive Wildlife Habitat in Trinity and Shasta Counties

September 19, 2019

During the week of August 26, wildlife officers at the California Department of Fish and Wildlife (CDFW) served seven search warrants in Trinity County and conducted one trespass grow investigation in Shasta County. Support for the missions were provided by the National Guard, the State Water Resources Control Board, the Trinity County Sheriff's Department and other local agencies.

A records search confirmed that none of the targeted properties had a state license or county permit to grow commercial cannabis, none possessed a Lake and Streambed Alteration Agreement and none were adhering to required CAL FIRE protocols.

The operations focused on protecting sensitive wildlife habitat that contribute to the survival of winter-run Chinook salmon, coho salmon, steelhead, cutthroat and rainbow trout, the foothill yellow-legged frog, the western pond turtle, deer and other species that are native to California's rich biodiversity.

"Our cannabis enforcement program in Redding continues to focus on critical habitat found in Trinity County where many important, threatened or endangered species call home," said David Bess, Deputy Director and Chief of the CDFW Law Enforcement Division. "Each of the targeted grows had numerous environmental violations ranging from water diversions to habitat destruction and in some cases extreme pollution near waterways."

In Trinity County, 27 suspects were contacted, 16 Fish and Game Code violations were documented, 33,783 illegal cannabis plants were eradicated and over 3,000 pounds of illegally produced cannabis product was confiscated. In Shasta County, wildlife officers arrested two suspects in a trespass cannabis grow near Ono where 1,163 cannabis plants were eradicated, and six environmental violations were documented. Felony charges are pending with both counties' District Attorney's Offices.

CDFW encourages the public to report illegal cannabis cultivation and environmental crimes such as water pollution, water diversions and poaching to the CalTIP hotline by calling (888) 334-2258 or texting information to "TIP411" (847411).

###

Media Contact:
Janice Mackey, CDFW Communications, (916) 207-7891

CDFW Steps in to Protect Animals at Wildlife Waystation

August 13, 2019

On August 11, 2019, the California Department of Fish and Wildlife (CDFW) was notified by the Wildlife Waystation, a wild animal refuge that houses exotic and domestic animals in Sylmar, that their Board of Directors had voted to surrender the facility's CDFW permit voluntarily and to close the facility. CDFW has implemented an incident command structure to handle daily operations and assist with the placement of animals.

As of this morning, CDFW is on site, actively ensuring that daily operations remain smooth at the facility, and is working with animal welfare organizations to place the animals into other facilities. CDFW will maintain oversight of the facility until all animals are placed appropriately.

CDFW's primary concern is for the health and welfare of the animals. CDFW is working collaboratively with Wildlife Waystation staff to ensure the best possible care during this transition.

The Wildlife Waystation was founded in 1976 and has been operating with a current permit issued by CDFW. The aging facility was extensively damaged in the 2017 Creek Fire and again in flooding in early 2019. Wildlife Waystation leadership is unable to repair the facility to current standards.

Media and the public are asked to please refrain from traveling to the property. The property is closed until further notice and access will not be granted. There is very limited road access and no cellular reception.

CDFW is contacting its network of local and national animal welfare organizations both for assistance and expertise in care of the animals as well as assistance in finding permanent placement for the more than 470 animals at the facility.

CDFW Deputy Director Jordan Traverso will be available for media interviews at the command center at the Hanson Dam Ranger Station at 10965 Dronfield Ave., Sylmar, Calif. until 3:30 p.m. She can also be reached at (916) 654-9937.

###

CDFW Expands Statewide Sampling for Chronic Wasting Disease

September 19, 2019

The California Department of Fish and Wildlife (CDFW) is increasing the scope of its monitoring and testing efforts for Chronic Wasting Disease (CWD) in California's deer and elk herds.

"While California has never had a report of CWD, increased testing is needed to establish with a high degree of certainty that there are no deer with CWD in California," said CDFW Wildlife Veterinarian Brandon Munk. "Keeping this disease out of our state is a top priority, both for wildlife managers and for hunters."

CWD is always fatal to deer and elk, and is an ongoing concern for hunters and managers throughout the country. Once CWD enters a herd, it is nearly impossible to eradicate. Although there are no known cases of CWD being transferred to humans, the Centers for Disease Control and Prevention (CDC) recommends not consuming meat or organs from any animal that tests positive for CWD.

CDFW's Wildlife Investigations Laboratory has set an ambitious goal to test 600 deer statewide during this year's hunting seasons and increasing that number to 2,000 statewide in the upcoming years.

Continued hunter cooperation will be key to achieving the CWD deer testing goals. CDFW will set up check stations during the various deer seasons, and hunters will be asked to bring their deer in for the quick removal of a lymph node for testing. CWD testing of hunter-taken deer is voluntary, and no meat is taken.

Information about specific locations and times of operation of CWD check stations in each of the state's deer zones and control hunt areas will appear on **CDFW's website**. Hunters can also contact **regional CDFW offices** to get check station schedules. Some offices may also offer onsite deer testing.

Some professional meat processors and butchers throughout the state are also partnering with CDFW to take samples from deer at the hunter's request. Hunters who may be unable to visit a check station or CDFW regional office for sampling are encouraged to ask their butcher ahead of time if sampling is available at the time of processing.

###

Media Contacts:
Brandon Munk*, CDFW Wildlife Investigations Lab, (916) 358-1194*
Nathan Graveline*, CDFW Big Game Program, (916) 445-3652*
Kirsten Macintyre*, CDFW Communications, (916) 322-8988*

California Department of Fish and Wildlife

CDFW News -

MENU

Paiute Cutthroat Trout Reintroduced to Native Habitat in High Sierra Wilderness

September 23, 2019

California’s native Paiute cutthroat trout, the rarest trout in North America, swims once again in its high Sierra home waters for the first time in more than 100 years.

California Natural Resources Secretary Wade Crowfoot, California Department of Fish and Wildlife (CDFW) Director Charlton H. Bonham and representatives from the USDA Forest Service, U.S. Fish and Wildlife Service (USFWS), Golden Gate Chapter of Trout Unlimited and Little Antelope Pack Station joined biologists to release 30 Paiute cutthroat trout of varying sizes into Silver King Creek in Alpine County, Calif., Sept. 18, 2019.

“You’ve got to celebrate good times. That’s what we’re doing here today,” said CDFW’s Bonham from the banks of Silver King Creek within the remote Carson-Iceberg Wilderness area of the Humboldt-Toiyabe National Forest. “If you forget to celebrate, you’re overlooking a remarkable success story – bringing these fish back home and celebrating a better California.”

Not since the early 1900s have genetically pure Paiute cutthroat trout occupied the 11-mile stretch of Silver King Creek between Llewellyn Falls and Snodgrass Creek that represents almost the entirety of the fish’s historic range.

“This is a lifetime achievement for those working to recover the rarest trout in North America,” said Lee Ann Carranza, acting field supervisor for the USFWS Reno office. “This remarkable partnership has allowed Paiute cutthroat trout to be returned to their entire native range without threat from non-natives.”

The Paiute cutthroat trout was one of the first animals in the nation listed as endangered in 1967 under the federal Endangered Species Preservation Act of 1966, now known as the Endangered Species Act. In 1975, the species was downlisted to federally threatened to allow for a special rule that would facilitate management of the species by the State of California.

A small native range, habitat degraded by historic sheep and cattle grazing, and competition from and hybridization with non-native trout introduced into Silver King Creek threatened the species with extinction.

Only a fortuitous turn of events saved the species from disappearing altogether. In the early 1900s, Basque sheepherders moved some of the fish outside of their native range, upstream of Llewellyn Falls. The waterfalls served as a barrier to the non-native trout below and safeguarded a genetically pure population of Paiute cutthroat trout above the falls, providing government agencies and advocates the chance to recover the species in the future.

Efforts to save and restore the species have spanned several decades and involved removing non-native fish and restocking Paiute cutthroat trout from source populations. Recreational fishing was closed within the Silver King Creek drainage in 1934. Later, grazing allotments were administratively closed so habitat could be restored.

At one time, only two small tributaries above Llewellyn Falls held genetically pure Paiute cutthroat trout. CDFW, the Forest Service and USFWS transferred some of these fish to other fishless, protected streams within the Silver King Creek watershed as well as four watersheds outside of the basin to create additional refuge populations to stave off extinction.

The effort to reintroduce Paiute cutthroat trout back into their historic home – the 11-mile main reach of Silver King Creek – began in 1994 when CDFW biologists explored Silver King Canyon and identified a series of waterfalls that served as historic barriers to upstream fish migration, isolating the Paiute cutthroat trout. The barriers could once again insulate Paiute cutthroat trout from encroachment from non-native trout if the non-native trout in Silver King Creek could be removed.

Wildlife officials prevailed over a decade of legal challenges to treat Silver King Creek and its tributaries with rotenone, a natural fish poison, to eliminate non-native trout and prepare Silver King Creek for the eventual return of Paiute cutthroats.

Silver King Creek and its tributaries were chemically treated from 2013 to 2015. State and federal partners monitored the creek for three years following the treatment to make sure all non-native fish were removed. Wildfires, floods and drought over the decades further complicated recovery efforts.

“The commitment of Forest Service, CDFW, USFWS, Lahontan Regional Water Quality Control Board, Trout Unlimited Golden Gate Chapter and Little Antelope Pack Station to move this project forward in the face of numerous challenges has been incredible,” said Bill Dunkelberger, Humboldt-Toiyabe

National Forest supervisor. “A project of this magnitude that took over several decades could not have been completed without state, federal and other partners working tirelessly together.”

The fish reintroduced into Silver King Creek on the afternoon of Sept. 18 were collected that morning from a source population in Coyote Valley Creek about 2 miles away and transported by mules to the banks of Silver King Creek. The fish were deposited into buckets filled with water from Silver King Creek to acclimate for several minutes before being released among cheers and applause – and a few tears – by biologists and others, some of whom have spent decades working toward the historic homecoming.

Restoring Paiute cutthroat trout to their native Silver King Creek nearly doubles the amount of habitat available to the fish and is considered key to their long-term survival and potential delisting.

Monitoring of the reintroduced fish and additional restocking of Paiute cutthroat trout into Silver King Creek from other refuge populations is planned in future years to aid genetic diversity and introduce different age classes into the creek to help natural reproduction.

Photos and video of the Sept. 18 reintroduction are available here:
ftp://ftp.wildlife.ca.gov/OCEO/Paiute%20Cutthroat%20Trout/

California Fish and Game Commission
Potential Agenda Items for December 2019 Commission Meeting

The next Commission meeting is scheduled for December 11-12, 2019 in Sacramento. This document identifies potential agenda items for the meeting, including items to be received from Commission staff and the California Department of Fish and Wildlife (DFW).

Wednesday, December 11: Wildlife- and inland fisheries-related and administrative items

1. General public comment for items not on the agenda (Day 1)
2. Tribal Committee
3. Wildlife Resources Committee
4. Notice: mammal hunting
5. Notice: waterfowl (annual)
6. Notice: wildlife areas/public lands and ecological reserves
7. Notice: Central Valley sport fishing (annual)
8. Notice: Klamath River Basin sport fishing (annual)
9. Adopt: possession of nongame animals (nutria)
10. Adopt: 90-day extension of Klamath River Basin 2084 Spring Chinook Salmon emergency rulemaking
11. Notice: Klamath River Basin 2084 Spring Chinook Salmon regular rulemaking (Certificate of Compliance)
12. Final consideration of petition to list foothill yellow-legged frog as an endangered or threatened species under the California Endangered Species Act
13. Discuss and potentially adopt a Delta Fisheries Management Policy and an amended Striped Bass Policy
14. Adopt Waterfowler's Hall of Fame resolutions
15. Wildlife and inland fisheries items of interest from previous meetings
16. Action on wildlife and inland fisheries petitions for regulation change
17. Action on wildlife and inland fisheries non-regulatory requests from previous meetings
18. Receive DFW informational items (wildlife and inland fisheries)
19. Executive (closed) session

Thursday, December 12: Marine-related and administrative items

20. General public comment for items not on the agenda (Day 2)
21. Executive director's report (staff report, legislative update)
22. Marine Resources Committee
23. Annual recreational ocean salmon and Pacific halibut regulations – Receive and discuss update on Pacific Fishery Management Council process and timeline, and automatic conformance to federal regulations
24. Receive annual report on DFW Statewide Marine Protected Areas Program management activities

25. Consider approving lease amendments applied for by Hog Island Oyster Company for its State Water Bottom Lease nos. M-430-10, M-430-11, M-430-12, and M-430-15 for aquaculture in Tomales Bay
26. Consider approving renewal of Charles Friend Oyster Company State Water Bottom Lease No. M-430-04 for aquaculture in Tomales Bay for a period of 15 years
27. Marine items of interest from previous meetings
28. Action on marine petitions for regulation change
29. Action on marine non-regulatory requests from previous meetings
30. Strategic planning update and potential goals and objectives
31. Receive DFW informational items (marine)
32. Administrative items (next meeting agenda, rulemaking timetable, new business)

State of California
Department of Fish and Wildlife

RECEIVED BY
FISH AND GAME COMMISSION
AT 9:00 A.M.
SEP 26, 2019

M e m o r a n d u m

Date: September 26, 2019

To: Melissa Miller-Henson
Executive Director
Fish and Game Commission

From: Charlton H. Bonham (Original signature on file)
Director

Subject: **Request for Changes to the Fish and Game Commission's Timetable for Anticipated Regulatory Actions**

The Department of Fish and Wildlife (Department) requests the following schedule changes to the Fish and Game Commission's (Commission's) 2019 regulatory timetable:

- Clarify the schedule for the "Simplification of Statewide Inland Fishing Regulations" rulemaking to amend Sections 5.00, 7.00, 7.50, and 8.10, T14, CCR.
  - The new proposed schedule is notice at the June 2020 meeting, discussion at the August 2020 meeting, and adoption at the October 2020 meeting.
  - The proposed regulations will be discussed at both the January Wildlife Resources Committee (WRC) and Tribal Committee (TC) meetings.
  - A special WRC meeting will be held in March and a recommendation will be sought to move the package to the full Commission in June.

- Move up a rulemaking to extend the Klamath River Basin 2084 Spring Chinook Salmon emergency rulemaking for Section 7.50(b)(91.2) for 90-days (Phase I) and a secondary 90-days (Phase II).
  - Accepting both Phase I and II will provide the time needed to implement a certificate of compliance to ensure that the emergency rulemaking remains in place until a permanent rulemaking is promulgated.

- Add a rulemaking to make the Klamath River Basin 2084 emergency rulemaking permanent by preparing a Certificate of Compliance for Section 7.50(b)(91.2).
    - The proposed schedule is notice at the December 2019 meeting, discussion at the February 2020 meeting, and adoption at the April 2020 meeting.

- Remove the rulemaking for possible amendments to the Upland (Resident) Game Bird annual (2020) regulation review for Section 300, since there are no expected changes for the regulations this year.
    - The revised meeting schedule is to remove the notice at the February 2020 meeting, discussion at the April 2020, and adoption at the June 2020 meeting.

If you have any questions or need additional information, please contact Regulations Unit Manager, Michelle Selmon at (916) 653-4674 or by email at Michelle.Selmon@wildlife.ca.gov.

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California Fish and Game Commission – Perpetual Timetable for Anticipated Regulatory Actions

(dates shown reflect the date intended for the subject regulatory action)

10/3/2019

ITEMS PROPOSED FOR CHANGE ARE SHOWN IN BLUE FONT

Quarterly Effective (For FGC Staff Use)	DFW RU Analyst	FGC Analyst	Lead	Regulatory Change Category	Action Date, Type and Location / Title 14 Section(s)	2019 OCT 8 TC Valley Center	OCT 9 FGC Valley Center	OCT 10 FGC Valley Center	NOV 5 MRC Sacramento	DEC 11 FGC Sacramento	DEC 12 FGC Sacramento	2020 JAN 16 WRC Los Angeles Area	JAN 17 TC Los Angeles Area	FEB 5 FGC Sacramento	FEB 6 FGC Sacramento	MAR TBD WRC Sacramento	MAR 17 MRC Santa Rosa	APR 15 FGC Sacramento	APR 16 FGC Sacramento	MAY 14 Teleconference	MAY 14 WRC Santa Rosa	JUN 24 FGC Santa Ana Area	JUN 25 FGC Santa Ana Area	JUL 21 MRC San Clemente Area	AUG 18 TC Fortuna Area	AUG 19 Fortuna Area	AUG 20 Fortuna Area	SEP 17 WRC Sacramento
					File Notice w/OAL by		08/13/19			10/15/19				12/10/19				02/18/20				04/28/20				6/30/20		
					Notice Published		08/23/19			10/25/19				12/20/19				02/28/20				05/08/20				07/03/20		
✱	OA	CC	MR	Hagfish Traps	180.6	E 10/1																						
✱	MR	ST	MR	Recreational and Commercial Pacific Herring (Fishery Management Plan Implementation)	26.50, 28.50, 28.60, 28.62, 55.00, 55.01, 55.02, 163, 163.1, 163.5, 164 and 705			A				E 1/1																
✱	MR	CC	MR	Experimental Fishing Permit (EFP) Program (Phase I)	90 and 704			D/A				E 1/1																
✱	MR	JS	WLB	Possession of Nongame Animals (Nutria)	473		D			A								E 4/1										
	OA	SF	FB	Klamath River Basin 2084 (Emergency)	7.50(b)(91.2)					EE 12/24																		
	OA	SF	FB	Klamath River Basin 2084 (Emergency) (First 90-day Extension)	7.50(b)(91.2)						A	E 12/24 through 3/22					EE 3/23											
	OA	SF	FB	Klamath River Basin 2084 (Emergency) (Second 90-day Extension)	7.50(b)(91.2)										A			E 3/23 through 6/20					EE 6/21					
	OA	SF	FB	Klamath River Basin 2084 (Implementing Certificate of Compliance)	7.50(b)(91.2)					N					D				A				E 6/21					
	MR	ST	WLB	Wildlife Areas/Public Lands and Ecological Reserves	550, 550.5, 551, 552, 630 and 702					N					D				A					E 7/1				
	MR	JS	WLB	Mammal Hunting	360, 361, 362, 363, 364 and 364.1					N					D				~~A~~					E 7/1				
	MR	JS	WLB	Waterfowl (Annual)	502, 507					N					D				A					E 7/1				
	OA	CC	FB	Central Valley Sport Fishing (Annual)	7.50(b)(5), (68), (124), (156.5)					N					D				D	A				E 7/1				
	OA	CC	FB	Klamath River Basin Sport Fishing (Annual)	7.50(b)(91.1)					N					D				D	A				E 7/1				
	~~MR~~	~~JS~~	~~WLB~~	~~Upland Game Bird~~	~~300~~							~~R~~			~~N~~				~~D~~				~~A~~				~~E 8/25~~	
	OA	JS	FB	Simplification of Statewide Inland Fishing Regulations [2]	5.00, 7.00, 7.50, 8.10							V	V			R							N				D	

RULEMAKING SCHEDULE TO BE DETERMINED

Quarterly Effective	DFW RU Analyst	FGC Analyst	Lead	Regulatory Change Category	Title 14 Section(s)	OCT 8	OCT 9	OCT 10	NOV 5	DEC 11	DEC 12	JAN 16	JAN 17	FEB 5	FEB 6	MAR TBD	MAR 17	APR 15	APR 16	MAY 14	MAY 14	JUN 24	JUN 25	JUL 21	AUG 18	AUG 19	AUG 20	SEP 17
			MR	Santa Cruz Harbor SalmonFishing (FGC Petition #2016-018)	TBD																							
			MR	European Green Crab (FGC Petition #2017-006)	TBD																							
			WLB	Wildlife Areas/Public Lands [1]	TBD																							
	~~OA~~	~~JS~~	~~FB~~	~~Simplification of Statewide Inland Fishing Regulations~~	~~5.00, 7.00, 7.50, 8.10~~							~~V~~																
✱	MR	CC	MR	Experimental Fishing Permit (EFP) Program (Phase II)	TBD																							
	~~OA~~	~~SF~~	~~FB~~	~~Klamath River Basin 2084 (Emergency) (90 day Extension - Phase I)~~	~~7.50(b)(91.2)~~																							
	~~OA~~	~~SF~~	~~FB~~	~~Klamath River Basin 2084 (Emergency) (90 day Extension - Phase II)~~	~~7.50(b)(91.2)~~																							
	~~OA~~	~~SF~~	~~FB~~	~~Klamath River Basin 2084 (Implementing Certificate of Compliance)~~	~~7.50(b)(91.2)~~																							
✱			MR	Commercial Kelp and Algae Harvest Management	165, 165.5, 704																							
✱				Possess Game / Process Into Food	TBD																							
✱			OGC	American Zoological Association / Zoo and Aquarium Association	671.1																							
				Night Hunting in Gray Wolf Range (FGC Petition #2015-010)	474																							
				Shellfish Aquaculture Best Management Practices	TBD																							
✱				Ban of Neonicotinoid Pesticides on Department Lands (FGC Petition #2017-008)	TBD																							
✱			MR	Commercial Pink Shrimp Trawl	120, 120.1, 120.2																							
✱			MR	Ridgeback Prawn Incidental Take Allowance	120(e)																							

EM = Emergency, EE = Emergency Expires, E = Anticipated Effective Date (RED "X" = expedited OAL review), N = Notice Hearing, D = Discussion Hearing, A = Adoption Hearing, V =Vetting, R = Committee Recommendation, WRC = Wildlife Resources Committee, MRC = Marine Resources Committee, TC = Tribal Committee

1: Includes FGC Petition #2018-003 & FGC Petition #2018-005; 2: Includes FGC Petition #2018-008

Marine Resources Committee (MRC) 2019 Work Plan
Scheduled Topics and Timeline for
Items Referred to MRC from California Fish and Game Commission
Updated September 30, 2019

Topic	Category	2019		2020
		JUL	NOV	MAR
		San Clemente	Sacramento	Monterey Area
Planning Documents				
MLMA Master Plan for Fisheries - Implementation Updates	Master Plan Implementation	X	X	X
Abalone FMP / ARMP Update	FMP	X	X	X
Aquaculture Programmatic Environmental Impact Report (PEIR)	Programmatic Plan			X
Regulations				
Aquaculture Lease Best Management Practices (BMP) Plan Requirements	DFW-FGC Project/ Rulemaking			X
Kelp & Algae Commercial Harvest	DFW Project/ Rulemaking	X	X	
Emerging/Developing Management Issues				
Aquaculture State Water Bottom Leases: Existing and future lease considerations	Lease Management Review			X
Special Projects				
California's Coastal Fishing Communities	MRC project	X	X	
Informational / External Topics of Interest				
Whale and Turtle Protections in the Management of the Dungeness Crab Fisheries		X	X	
Stakeholder informational presentation on aspects of State recreational fisheries management not under FGC regulatory authority		X		
Stakeholder informational presentation on aspects of State commercial fisheries management not under FGC regulatory authority			X	

KEY: X Discussion scheduled X/R Recommendation developed and moved to FGC

STAFF SUMMARY FOR AUGUST 7-8, 2019

19. EXPERIMENTAL FISHING PERMIT PROGRAM (PHASE 1)

Today's Item **Information** ☐ **Action** ☒

Consider authorizing publication of notice of intent to adopt experimental fishing permit (EFP) regulations, to allow for issuing EFPs to fishermen that were issued experimental gear permits in 2018 for the box crab experimental gear permit program.

Summary of Previous/Future Actions

• FGC approves two-phase rulemaking approach	Jun 12-13, 2019; Redding
• DFW update and MRC discussion of two-phase rulemaking approach	Jul 11, 2019; MRC, San Clemente
• **Today's notice hearing**	**Aug 7-8, 2019; Sacramento**
• Discussion/adoption hearing	Oct 9-10, 2019; Valley Center

Background

At its Dec 12-13, 2018 meeting, FGC approved issuing experimental gear permits to applicants who had requested to participate in a collaborative fisheries research program to study the brown box crab (*Lopholithodes foraminiatus*) and the potential for developing a new targeted fishery in California (hereinafter referred to as the box crab experimental program). As discussed in a previous staff summary (Exhibit 4), pursuant to Fish and Game Code Section 8606 FGC approved eight experimental gear permits for issuance by DFW; the eight permits will expire on Mar 31, 2020.

Fish and Game Code Section 8606 was repealed effective Jan 1, 2019, thus eliminating FGC's ability to renew or authorize any new experimental gear permits. A new Fish and Game Code Section 1022 was created, which provides for establishing an EFP program upon FGC adopting regulations. Section 1022 also provides FGC with expanded authority to authorize, for research, educational, limited testing, data collection, compensation fishing, conservation engineering, or exploratory fishing, or any combination of these purposes, an EFP that allows commercial or recreational marine fishing activity otherwise prohibited by state fishing laws or regulations.

With the repeal of Fish and Game Code Section 8606, and absent regulations implementing Fish and Game Code Section 1022, the box crab experimental program cannot be continued beyond the Mar 31, 2020 expiration of the existing permits. To provide a pathway for the box crab experimental program to continue while a new EFP program is thoughtfully developed, DFW proposed a two-phase rulemaking approach that FGC approved in Jun 2019. Phase 1 proposes a process for issuing EFPs to fishemen approved for box crab experimental fishing gear permits in Dec 2018. Thus, today's item is intended to ensure that the current box crab experimental program can continue while a larger programmatic rulemaking (Phase 2) can be developed with stakeholder engagement.

Proposed Regulations

The proposed regulations in Phase 1 will add new Chapter 5.6, Experimental Fishing Permit Program, containing new Section 90, Issuance of Experimental Fishing Permits, to Title 14. Proposed Section 90 will establish the process for FGC approval and DFW issuance of EFPs to those applicants previously approved to receive a box crab experimental gear permit, and includes the following concepts:

- The applicant shall submit a written request for an EFP at least 60 days prior to the expiration date of their current experimental gear permit.
- No more than eight valid EFPs will be issued at any one time.
- FGC may establish standard terms applicable to all fishery participants.
- FGC may approve the adoption, amendment, or repeal of special conditions unique to the experimental fishery set forth in Form DFW 1085 as it deems necessary for research and the conservation and management of marine resources and the environment.
- DFW shall notify a permittee at least 30 days before recommending a change to the special conditions of the EFP issued to that permittee.
- Access to future permits, if a fishery is developed, is not implied by participation in the EFP program.

The proposed regulations will also add new Section 704, Experimental Fishing Permits; Fees and Forms to Title 14, which will stipulate the annual box crab EFP fee of $4,487.75. Pursuant to Fish and Game Code subdivision 1022(g), FGC is authorized to charge a fee as necessary to fully recover, but not exceed, all reasonable implementation and administrative costs of DFW and FGC related to the EFP. A detailed discussion of these costs can be found in the draft initial statement of reasons (ISOR; Exhibit 2) and draft economic and fiscal impact statement (Std 399; Exhibit 6).

Proposed Section 704 will also incorporate by reference the Experimental Fishing Permit Terms and Conditions Form DFW 1085 (New 08/01/2019) (Exhibit 3), which identifies the person(s) and vessel authorized to conduct activities under the EFP and specifies the standard terms and special conditions to which EFP permit holders will be subject. The proposed standard terms and special conditions are consistent with those used to issue the experimental fishing gear permits (Exhibit 5).

Significant Public Comments

A fishery organizer expressed inspiration from DFW's work to date on the box crab EFPs and intends to convene a fisherman's data review committee to discuss approaches to experimental fisheries, beginning with a discussion of whale entanglement and marine mammal conflict resolution (Exhibit 8).

Recommendation

FGC staff: Authorize publication of the notice and request the effective date as recommended by DFW.

DFW: Authorize publication of the notice as detailed in the draft ISOR (Exhibit 2), and request that the Office of Administrative Law make the regulation effective on or before January 1, 2020 (Exhibit 1).

Exhibits

1. DFW memo transmitting ISOR and providing overview of California Environmental Quality Act categorical exemptions, received Jul 22, 2019
2. Draft ISOR
3. Draft form DFW 1085, Experimental Fishing Permit Terms and Conditions
4. Staff summary for Agenda Item 11, Dec 12-13, 2018 FGC meeting (for background only)
5. Box crab experimental gear permit terms and conditions, dated Dec 20, 2018 (for background only)
6. Draft economic and fiscal impact statement (Std. 399)
7. Draft notice of exemption
8. Email from Chris and Dominique Miller, concerning a fisherman's data review committee to discuss experimental fisheries, received Jul 25, 2019
9. DFW presentation

Motion/Direction

Moved by _____________ and seconded by _____________ that the Commission authorizes publication of a notice of its intent to adopt Chapter 5.6, containing Section 90, and adopt Section 704, related to experimental fishing permit regulations.

STATE OF CALIFORNIA
FISH AND GAME COMMISSION
INITIAL STATEMENT OF REASONS FOR REGULATORY ACTION

Add Chapter 5.6, Section 90; and Add Section 704,
Title 14, California Code of Regulations
Re: Experimental Fishing Permit Program (Phase 1)

I. Date of Initial Statement of Reasons: July 22, 2019

II. Dates and Locations of Scheduled Hearings

(a) Notice Hearing: Date: August 8, 2019
Location: Sacramento, CA

(b) Discussion/Adoption Hearing: Date: October 10, 2019
Location: Valley Center, CA

III. Description of Regulatory Action

(a) Statement of Specific Purpose of Regulation Change and Factual Basis for Determining that Regulation Change is Reasonably Necessary:

Unless otherwise specified, all section references in this document are to Title 14 of the California Code of Regulations (CCR).

The California Department of Fish and Wildlife (Department) is proposing to add new Chapter 5.6, Experimental Fishing Permit (EFP) Program, which will contain new Section 90, Issuance of Experimental Fishing Permits. New Section 704, Experimental Fishing Permits; Fees and Forms, relating to fees and forms associated with issuance of EFPs is also proposed to be added.

The proposed regulations implement, in part, Assembly Bill (AB) 1573 (also known as the California Fisheries Innovation Act of 2018) which became effective on January 1, 2019. This legislative action repealed the experimental gear permit (EGP) provisions in Section 8606, Fish and Game Code (FGC), and added a new FGC Section 1022, providing for an EFP program to facilitate fishery-related exploration and experimentation to inform fishery management.

Now-repealed FGC Section 8606 had required the Fish and Game Commission (Commission) to encourage the development of new types of commercial fishing gear and new methods of using existing commercial fishing gear by approving EGPs to be issued by the Department. AB 1573 eliminated the EGP, which focused solely on commercial fishing gear types, and replaced it with the more expansive EFP that, under the authority of new FGC Section 1022, could be issued for both recreational and commercial fishing activities.

Under new FGC Section 1022, the Commission may authorize, for research, educational, limited testing, data collection, compensation fishing, conservation engineering, or exploratory fishing, or any combination of these purposes, an EFP to be issued by the Department that authorizes commercial or recreational marine fishing activity otherwise prohibited by state fishing laws or regulations. Activities conducted under an EFP would be subject to certain Standard Terms and Special Conditions as deemed necessary by the Commission to ensure the protection of marine resources and are additionally required to be consistent with policies set forth in FGC Section 7050 and any applicable fishery management plan.

Existing Experimental Gear Permits

At its December 12, 2018 meeting, and prior to the repeal of FGC Section 8606, the Commission approved the issuance of EGP permits to applicants who had requested to participate in a collaborative fisheries research program to study the brown box crab (*Lopholithodes foraminiatus*) and the potential for development of a new targeted fishery in California (hereinafter referred to as the box crab program). As discussed in the Commission staff summary report for that meeting (refer to section III(e)), the Commission approved eight EGPs for the box crab program to be issued by the Department in order to ensure protection of the box crab resource and adequate allocation of landings for cost recovery. These permits were distributed according to fishing study regions, with three permits issued to fishermen operating north of Point Conception and five permits issued to fishermen operating south of Point Conception and are valid for 12 months starting April 1, 2019 with potential for annual renewal for up to three years (for a total of four years of permitted fishing).

Consequently, following the repeal of FGC Section 8606, new regulations pursuant to FGC Section 1022 need to be established in Title 14, CCR, to support the continuation of the box crab program before the EGPs expire on March 31, 2020. The proposed regulations will ensure that current research on a potential box crab fishery can continue while a larger programmatic rulemaking can be developed to build out an EFP program pursuant to FGC 1022.

The Department and the Commission will take a two-phased approach to fully implement FGC Section 1022. Department and Commission staff were concerned that public scoping would be limited to a one- to two-month window if a full build out of the EFP program were to be in place by April 1, 2020. This amount of time for public involvement in the development of a new program is insufficient. Therefore, it was decided to split the EFP program building into two phases. The first phase will produce a process for issuing EFPs for the continuation of the box crab program (the intent of this rulemaking), while the second phase will build in more time for public scoping to achieve a fully developed EFP program as envisioned by the legislature pursuant to FGC Section 1022.

Current Regulations

The eight existing EGPs that were approved by the Commission and issued by the Department in 2018 pursuant to FGC Section 8606 will expire on March 31, 2020. Since the repeal of FGC Section 8606, there are currently no regulations in place to enable the issuance of EFPs pursuant to FGC Section 1022 for the purpose of continuing the research on a potential box crab fishery. Under current law (FGC subdivision 1022(b)), the

Commission has the authority to establish regulations to implement an EFP program, including an expeditious process for Department review, public notice and comment, Commission approval, and prompt Department issuance of EFPs. The proposed regulations will be promulgated under this authority.

Proposed Regulations

The proposed regulations will establish a new Chapter 5.6, Experimental Fishing Permit program, containing new Section 90, Issuance of Experimental Fishing Permits; and additionally, establish new Section 704, Experimental Fishing Permits; Fees and Forms.

<u>Add new Chapter 5.6, Title 14, CCR; Experimental Fishing Permit Program.</u>

This regulatory proposal will add new Chapter 5.6, containing new Section 90. Regulations within Chapter 5.6 will primarily describe the overarching strategy to establish the EFP Program. This new Chapter is necessary to provide a coherent framework in regulations to implement the new EFP program, which will be established through the dual phase approach outlined above.

<u>Add new Section 90, Title 14, CCR; Issuance of Experimental Fishing Permits.</u>

The proposed regulations in new Section 90 will establish the process for issuing the new EFPs for the continuation of the box crab program approved by the Commission in 2018.

Subsection 90(a) allows the Department to issue EFPs to those applicants previously approved by the Commission in 2018 to receive an EGP pursuant to FGC Section 8606.

Subsection 90(a)(1) states that the permit will be issued as an “experimental fishing permit” pursuant to FGC Section 1022, and valid for a term of one year from April 1 through March 31.

Subsection 90(a)(2) requires applicants for an EFP to submit a written request to the Department at least 60 days prior to the expiration date of their current permit. This requirement will enable the Department to fulfill its obligations under subsection 90(a)(3) to review and determine that all applicants meet the Standard Terms and Special Conditions of the EFP and are thus qualified to receive an EFP.

Subsection 90(a)(3) states that each applicant must be found by the Department to be capable of complying with the Standard Terms and Special Conditions of the EFP to be eligible to receive an EFP.

Subsection 90(a)(3)(A) states that EFPs will be first issued to current holders of EGPs that were approved by the Commission in 2018 and who submitted a written request for issuance of an EFP pursuant to subsection 90(a)(2).

Subsection 90(a)(3)(B) states that if less than eight EFPs are issued, the Department may issue an EFP to another applicant previously approved by the Commission in 2018 for an EGP, so long as there are no more than eight valid permits at any one time. This provision will enable the Department to maintain an adequate number of research participants should any one of the current permit holders drop out of the box crab program before the experimental research period is complete or is deemed ineligible to receive an EFP by the Department.

Subsection 90(a)(3)(C) states that failure to adhere to the Standard Terms and Special Conditions of the EFP, or violation of any fishing laws while operating under an EFP, is unlawful and may result in immediate suspension or denial of the request for issuance of an EFP.

Subsection 90(a)(4) requires the timely payment of the fee for the EFP as set forth in Section 704. Pursuant to FGC subdivision 1022(g), the fee is sufficient to fully recover, but not exceed, all reasonable implementation and administrative costs related to the box crab program (e.g. permit approval, management, and monitoring of the program).

Subsection 90(b)(1) establishes that Form DFW 1085 (New 08/01/2019) Experimental Fishing Permit Terms and Conditions will enumerate the Standard Terms applicable to all participants in the experimental box crab fishery.

Subsection 90(b)(2) requires that the permittee comply with the Special Conditions approved by the Commission and attached to Form DFW 1085. The Special Conditions of the experimental fishing permit will be consistent with the purpose of the experimental gear permit Special Conditions as approved by the Commission in 2018, and will allow for the continued operation of the experimental box crab fishery in a manner that is compliant with the requirements set forth in FGC subdivisions 1022(a)(1) and 1022(a)(2) relating to fishery management and the protection of marine resources.

Subsection 90(b)(2)(A) establishes that, based upon a recommendation from the Department, the Commission may approve the adoption, amendment, or repeal of the Special Conditions of the EFP as it deems necessary for research and the conservation and management of marine resources and the environment.

Subsection 90(b)(2)(B) requires the Department to inform permittees of pending changes to the Special Conditions of the EFP at least 30 days prior to making a recommendation to the Commission to consider such changes. This is necessary to make specific the criteria of the EFP and ensure that an EFP permit holder is aware of their obligations. Additionally, subsection 90(b)(2)(B) is necessary to ensure that a process is in place to properly notify permit holders in a timely manner and allows for public review and comment before the Commission considers any modifications to the Special Conditions of the EFP.

Subsection 90(c) clarifies that access to future permits, if a fishery is developed, is not implied by participation in the experimental fishing permit program. The specific provisions of any future fishery (if found viable) are not known at this time. If permits are to be issued in a new fishery it will be under conditions fair to all interested parties.

These provisions are necessary to establish a procedure to issue EFPs pursuant to FGC Section 1022. The proposed regulations will ensure that current EGP permit holders participating in the box crab program are properly permitted to continue to conduct the experimental fishing research once the term of the EGPs expires on March 31, 2020. The proposed regulations are also necessary to maintain a sufficient number of participants in the box crab program if any of the eight box crab permits becomes available prior to the completion of the experimental research period. The establishment of Standard Terms and Special Conditions, and procedure for subsequent amendments to the Special Conditions, is necessary to ensure that the EFP program is compliant with the requirements of FGC subdivision 1022(a)(2) to ensure protection of marine resources. Owing to the experimental nature of this fishery program, the proposed regulations will enable the Commission, based upon the best available science and recommendations provided by the Department, to determine which Special Conditions of the EFP are necessary for protection of marine resources (pursuant to FGC subdivision 1022(a)(2)), and amend those Special Conditions in the future in response to new scientific information and Department recommendations.

<u>Add new Section 704, Title 14, CCR; Experimental Fishing Permits; Fees and Forms.</u>

Subsection 704(a)(1) will stipulate the box crab EFP fee pursuant to FGC subdivision 1022(g) that authorizes the Commission to charge a fee as necessary to fully recover, but not exceed, all reasonable implementation and administrative costs of the Department and Commission related to the EFP.

Subsection 704(a)(2) provides that Form DFW 1085 (New 08/01/2019) Experimental Fishing Permit Terms and Conditions will be incorporated by reference (see Attachment). The Standard Terms and Special Conditions of form DFW 1085 are outlined below and may be adjusted in the future as research data dictate (as per the procedure set forth in subsection 90(b)(2)(A)).

Subsection 704(b) states that the EFP fee is subject to an annual adjustment, pursuant to Section 699.

As discussed above, the box crab EFP program is a multi-year research collaboration developed and funded by the Department, the Ocean Protection Council, the Resources Legacy Fund, and interested commercial trap fishermen for the purpose of collecting biological information and exploring a new directed fishery for box crab. The Department has estimated the annual reasonable Department costs with administering and implementing this EFP program, including cost-sharing and participant contributions (Table 1). Several parameters were used to calculate the costs to the Department, including staff time, travel and meetings, and enforcement. Because the Department's Marine Region has management interest in investigating the feasibility of a box crab fishery, some of the cost of developing and managing the box crab EFP program would be shared by the Department by means of excluding the Marine Region's permanent staff time from the overall Department costs. The remaining annual cost of the EFP program to be shared by program participants (i.e., permit holders) amounts to $35,902 (for eight box crab permits), which yields a final permit fee of $4,487.75. This permit fee is specified in subsection 704(a)(1) of the proposed regulations and is subject to an annual adjustment pursuant to Section 699 (stated in subsection 704(b)). As mentioned above, the proposed regulations are necessary to recover all reasonable implementation and administrative costs relating to the box crab EFP, consistent with FGC subdivision 1022(g).

Table 1. Annual cost breakdown for the box crab experimental fishery permit.

Annual Department Costs[1] for 8 Box Crab Permits			
ENFORCEMENT	**Hours**	**Rate ($/hr)**	**Subtotal**
Patrol Vessel	91	$196	**$17,836**
Overhead			$4,337.72
Total			$22,173.72
LICENSE & REVENUE BRANCH (LRB)			
Permit Administration	**Hours**	**Rate ($/hr)**	**Subtotal**
Staff service analyst (SSA)	40	$31.45	$1,258
Program technician (PT)	2	$23.15	$46
Staff services manager (SSMI)	8	$44.64	$357
Staff services manager III (SSMIIII)	4	$54.45	$218
Total Salary/Wages			**$1,879**
Staff Benefits			$991
Subtotal Personnel			**$2,870**
Overhead			$698.03
LRB Total			$3,568
REGION 7 - MARINE	**Hours**	**Rate ($/hr)**	**total costs**
Permanent Staff			
Senior Environmental Scientist (salary + benefits)[2]	1,330	$58.69	$ 78,047
Temporary Staff			
Scientific Aid (Santa Barbara)	145	$15.53	$2,252
Scientific Aid (San Diego)	195	$15.53	$3,028
Temporary Staff Benefits			$2,892
Subtotal Temp Help			**$8,172**
Overhead			$1,988
Temp Help Total			**$10,160**
Total Annual Cost for 8 Permits			$35,901.99
Cost per Permit[3]			$4,487.75

Sources: California Department of Fish and Wildlife (Department) Law Enforcement, License and Revenue Branch, and Marine Region; 2018-19 California Department of Human Resources (CalHR) salary schedule, 2018-19 Department benefit and overhead rates.

Notes:

1 In addition to Department costs, the box crab program is supported by grants from the Ocean Protection Council and the Resources Legacy Fund, the California Sea Grant, and National Oceanic and Atmospheric Administration (NOAA) Saltonstall-Kennedy Grant Program.

2 As the Department's share of the cost, it will not be reimbursed for the Marine Region's permanent staff time to oversee the program through the receipt of the permit fee.

3 The permit fee is an annual cost-share amount for each program participant (i.e., permit holder). The box crab permit fee was derived from the Department costs (minus the Marine Region's salary and benefits for permanent staff) divided by the number of permits approved by the Commission and issued by the Department in December 2018 (i.e., eight permits).

Form DFW 1085 (New 08/01/2019), Experimental Fishing Permit Terms and Conditions

Subsection 704(a)(2) sets forth the compliance criteria for the EFP. The proposed regulations will incorporate by reference the Experimental Fishing Permit Terms and Conditions, form DFW 1085 (New 08/01/2019), that requires the following information:

- Name and address of the permittee,
- Name and address of a secondary permit operator,
- Vessel name and identification number,
- Description of the authorized fishing activity, and
- Standard Terms and Special Conditions that EFP holders will be subject to.

This information required on the form, and the Standard Terms and Special Conditions expressed there, is necessary to clearly identify and ensure that experimental fishing operations are conducted only on the vessel and by the individuals to which the EFP was issued and will assist in enforcement of this requirement.

The Standard Terms and Special Conditions are consistent with those used to issue EGPs previously approved by the Commission at its December 12, 2018 meeting, prior to the repeal of FGC Section 8606, which include the following:

STANDARD TERMS. These are terms of the EFP which are generally applicable to any fishery. These Standard Terms are necessary to ensure consistency with other state fishing laws and regulations and provide clarity by detailing the operating procedures and requirements for which all EFP permit holders must abide:

1. An Experimental Fishing Permit number will be provided by the License and Revenue Branch (LRB) for this activity, and it will be valid for a term of one year commencing on ___________ and ending on ____________.
2. The permit shall be operated only on the vessel named above. The permittee may designate up to one other permit operator who may also take the authorized species from the vessel named on this permit. Either the primary permittee or the secondary operator must be aboard the vessel, and both are responsible and accountable for meeting the requirements and limits of this permit.
3. Pursuant to FGC Section 7857(d), a valid copy of the original Department issued Automated License Data System permit shall be attached to a signed copy of this form and be on the vessel when activities are being conducted under the authority of this permit.
4. The permittee and any person who assists the permittee, must possess a valid commercial fishing license issued pursuant to FGC Section 7850, prior to engaging in any commercial fishing operations authorized by this permit.
5. The permittee shall possess a valid commercial boat registration issued pursuant to FGC Section 7881, for the vessel named above and display the Department Boat Registration numbers in plain sight on each side of the vessel.
6. The permittee and second operator must comply with all appropriate state and federal laws and regulations, including but not limited to those relating to protected species, minimum size limits, and seasons or areas closed to fishing that are not otherwise exempted by the permit (see special conditions).

7. The permittee and second operator shall cooperate with the Department by allowing personnel designated by the Department to board the fishing vessel operated by the permittee under this permit, to observe or inspect equipment, procedures, or catch, on any fishing trip for as long as the trip may last throughout the duration of the permit.

a. The vessel must display a current Coast Guard safety decal

b. The vessel must be capable of safely carrying an observer and provide that observer with accommodations equivalent to those provided to the captain and crew for both single and multi-day trips if multi-day trips are conducted.

SPECIAL CONDITIONS. These are conditions approved by the Commission specifically for the fishery proposed and attached to form DFW 1085. The Special Conditions are necessary to ensure that activities conducted under an EFP are consistent with FGC subdivisions 1022(a)(1) and 1022(a)(2), which direct the Commission to determine those Special Conditions necessary to protect marine resources and to ensure that activities conducted under an EFP are consistent with any applicable fishery management plan and the policies set forth in FGC Section 7050 relating to the management, conservation, and sustainable use of California's marine living resources.

It is not possible to predict all future aspects of any new fishery, technology, gear, or other subjects related to the experimental fishing permit. The purpose of the EFP is to discover the characteristics of experimental proposals while active on the water. The Commission may therefore adopt, amend, or repeal Special Conditions as it deems necessary for research and the conservation and management of marine resources and the environment with notice as required by subsections 90(b)(2)(A) and 90(b)(2)(B).

The following general categories of Special Conditions may be necessary to protect marine resources, fill research and data needs and ensure compliance with the purposes of the permit. These general categories are provided as examples of the types of Special Conditions that the Commission may adopt, amend, or repeal pursuant to the parameters set forth in subsection 90(b)(2)(A), and is not intended to be an exhaustive list:

A. The amount and size of each species that can be harvested and/or landed during the term of the permit, including trip, annual or other harvest limitations.

B. A citation of current state fishing laws and regulations from which the permit is exempted.

C. The time(s) and place(s) where activities may be conducted.

D. The gear type, design specifications, and amount that may be used by each person or vessel operating under the permit, and any other restrictions placed on the methods of gear use.

E. Whether fishery observers, electronic equipment or both are to be carried on board vessels operating under the permit and any necessary conditions to provide for personnel safety.

F. Data reporting requirements necessary to document fishing and research activities and established timeframes and formats for submission of the data to the department.

G. Other Special Conditions as may be necessary to fill research and data needs and ensure compliance with the purposes of the permit.

(b) Goals and Benefits of the Regulation:

It is the policy of the State to ensure the conservation, sustainable use, and, where feasible, restoration of California's marine living resources for the benefit of all the citizens of the state. The objectives of this policy include, but are not limited to, support and promote scientific research on marine ecosystems and their components to develop better information on which to base marine living resource management decisions, manage marine living resources on the basis of the best available scientific information and other relevant information that the Commission or Department possesses or receives, and to involve all interested parties, including, but not limited to, individuals from the sport and commercial fishing industries, aquaculture industries, coastal and ocean tourism and recreation industries, marine conservation organizations, local governments, marine scientists, and the public in marine living resource management decisions.

In April 2018, the Department determined that the harvest of all non-Cancer crabs, including box crab, is an emerging fishery. Since 2014, the Department landings data for box crab showed a rapid increase. To address the biological concerns and industry interest, a collaborative box crab program between the Department, academics, NGOs, and interested commercial trap fishermen utilizing the Commission-approved EGPs to collect data and evaluate the potential for a box crab targeted fishery was developed. The box crab program supports emerging fisheries as mandated by the Marine Life Management Act (FGC Section 7090) by providing the necessary information (i.e., biological information about the species and sustainable harvest levels) to determine if the box crab resource represents a viable new fishing opportunity.

However, with the repeal of FGC Section 8606, the box crab EGPs must come into compliance with new FGC Section 1022. The eight existing EGPs that were approved by the Commission and issued by the Department in 2018 pursuant to FGC Section 8606 will expire on March 31, 2020. Since the repeal of FGC Section 8606, there are currently no regulations in place to enable the issuance of EFPs pursuant to FGC Section 1022 for the purpose of continuing the research on a potential box crab fishery. Under current law (FGC subdivision 1022(b)), the Commission has the authority to establish regulations to implement an EFP program, including an expeditious process for Department review, public notice and comment, Commission approval, and prompt Department issuance of EFPs. The proposed regulations will implement the first phase of a statewide EFP program by ensuring regulations are in place to issue new box crab EFPs no later than April 1, 2020. The benefit of the proposed regulations will ensure that existing box crab permit holders can continue to collect data for management and test the viability of a box crab fishery, which will inform future management strategies for this emerging fishery.

(c) Authority and Reference Sections from Fish and Game Code for Regulation:

Section 90:
Authority: Section 1022 Fish and Game Code.
Reference: Section 1022, Fish and Game Code.

Section 704:
Authority: Sections 713, 1022, and 1050, Fish and Game Code.
Reference: Sections 713, 1022, and 1050, Fish and Game Code.

(d) Specific Technology or Equipment Required by Regulatory Change:

None. As discussed above, the requirements to participate (e.g., electronic monitoring equipment, operating vessel capacity, trap design specifications, and buoy marking requirements) in the box crab EFP will be consistent with those requirements used to issue EGPs previously approved by the Commission at its December 12, 2018 meeting, prior to the repeal of FGC Section 8606.

The use of these specific technologies will ensure that existing box crab permit holders can continue to collect data for management and test the viability of a box crab fishery, which will inform future management strategies for this emerging fishery.

(e) Identification of Reports or Documents Supporting Regulation Change:

Staff summary for Agenda Item 11. Box Crab Experimental Gear Permit, December 12-13, 2018 Commission meeting.

Box Crab Experimental Gear Permit Terms and Conditions approved by the Commission and issued by the Department on December 20, 2018.

(f) Public Discussions of Proposed Regulations Prior to Notice Publication:

March 13, 2019, Teleconference with The Nature Conservancy (TNC) (the sponsor of AB 1573). The Department and Commission staff discussed with TNC the rulemaking process for the EFP program and public scoping opportunities.

March 20, 2019, Sacramento, California. The Department briefed the Marine Resources Committee (MRC) on the development of the EFP implementing regulations.

July 11, 2019, San Clemente, California. The Department updated the MRC on developing the EFP program in two phases to address the need to have regulations in place by April 1, 2020 for the continuance of experimental box crab research previously approved by the Commission in 2018 while ensuring there is sufficient time for meaningful public scoping and participation in the development of an EFP program pursuant to FGC Section 1022.

IV. Description of Reasonable Alternatives to Regulatory Action

(a) Alternatives to Regulation Change:

No alternatives were identified by or brought to the attention of Commission staff that would have the same desired regulatory effect.

(b) No Change Alternative:

Under the no change alternative, the eight existing EGPs for the box crab program that were approved by the Commission and issued by the Department in 2018 pursuant to FGC Section 8606 will expire on March 31, 2020. Since the repeal of FGC Section 8606, there are currently no regulations in place to enable the issuance of EFPs pursuant to FGC Section 1022 to continue to support the collaborative research being conducted on the emerging box crab fishery as required by FGC Section 7090.

V. Mitigation Measures Required by Regulatory Action

The proposed regulatory action does not impose any mitigation measures.

VI. Impact of Regulatory Action

The potential for significant statewide adverse economic impacts that might result from the proposed regulatory action has been assessed, and the following initial determinations relative to the required statutory categories have been made:

(a) Significant Statewide Adverse Economic Impact Directly Affecting Businesses, Including the Ability of California Businesses to Compete with Businesses in Other States:

The proposed action will not have a significant statewide adverse economic impact directly affecting business, including the ability of California businesses to compete with businesses in other states.

No businesses are expected to be impacted by the proposed regulations because the regulations proposed implement a process for the Commission to authorize the Department to issue EFPs and establishes the same fee for the EFPs as was established for the EGPs. The economic impact to the state is anticipated to be unchanged with no adverse impacts to California businesses or their ability to compete with businesses in other states.

(b) Impact on the Creation or Elimination of Jobs Within the State, the Creation of New Businesses or the Elimination of Existing Businesses, or the Expansion of Businesses in California; Benefits of the Regulation to the Health and Welfare of California Residents, Worker Safety, and the State's Environment:

The Commission does not anticipate any impacts on the creation or elimination of jobs, the creation of new business, the elimination of existing businesses or the expansion of businesses in California because the proposed regulatory action will enable the continuation of an existing experimental fishery with no change.

The Commission anticipates indirect benefits to the health and welfare of California residents. Providing opportunities for a potential box crab fishery encourages consumption of a nutritious food. The Commission anticipates benefits to the state's environment as the EFP program would be a proactive approach to fisheries management which will ensure the protection of marine resources and foster sustainable fisheries and a healthy marine environment.

The Commission does not anticipate any benefits to worker safety because the proposed regulations would not have any impact on working conditions.

(c) Cost Impacts on a Representative Private Person or Business:

The proposed regulations are necessary to establish a process for the issuance of Experimental Fishing Permits to replace previously approved Experimental Gear Permits for the box crab program. The fee determination for the box crab experimental fishery permit is shown in Table 1 above. The annual fee amount of $4,487.75 is essentially unchanged from the fee for the experimental gear permits issued in December 2018. Thus, current box crab permit holders will not incur additional compliance costs associated with the proposed permit fee of $4,487.75. Should a permit become available among the eight allowable at any one time, the new entrant would incur a new annual $4,487.75 permit fee cost.

(d) Costs or Savings to State Agencies or Costs/Savings in Federal Funding to the State:

The Department has a duty to recover all reasonable implementation and administrative costs relating to the EFP program pursuant to Fish and Game Code subdivisions 1022(g) and 1050(e) (see Table 1). Subsection 704(a)(1) will stipulate the box crab EFP fee pursuant to FGC subdivision 1022(g) that authorizes the Commission to charge a fee as necessary to fully recover, but not exceed, all reasonable implementation and administrative costs of the Department and Commission related to the EFP. No costs/savings in Federal funding to the state are anticipated.

(e) Nondiscretionary Costs/Savings to Local Agencies: None.

(f) Programs Mandated on Local Agencies or School Districts: None.

(g) Costs Imposed on Any Local Agency or School District that is Required to be Reimbursed Under Part 7 (commencing with Section 17500) of Division 4, Government Code: None.

(h) Effect on Housing Costs: None.

VII. Economic Impact Assessment

The continuation of the experimental box crab fishery is anticipated to provide approximately $254,826 in total economic output throughout the state marine economy. The state marine economy consists of two industry sectors: 1) fishing operations, transport, and support and; 2) seafood sales, and processing. These sectors include several different marine-related industries: commercial harvesters, seafood processors and dealers, seafood wholesalers and distributors, and retail seafood sales.

The total economic output is derived by first determining the ex-vessel value of the box crab fishery by multiplying the harvest quota of 36,000 pounds times the average market price of $3.97 per pound. The additional value generated from the direct ex-vessel value is estimated with output multipliers to derive the indirect and induced impacts that are summed in the total economic output value.

Output multipliers reflect the incremental re-spending of a specific initial direct expenditure. Direct expenditures are received by supporting businesses who then spend all or a portion of that revenue on additional goods or services. The second-tier business spending is characterized as indirect impacts. Business spending on wages that is received by workers who then spend that income is characterized as induced impacts. Commercial harvest value thus multiplies throughout the economy with the indirect and induced impacts of the initial direct expenditure.

(a) Effects of the Regulation on the Creation or Elimination of Jobs Within the State:

The Commission does not anticipate any impacts to the creation or elimination of jobs within the State. The proposed EFP program is not likely to have an impact on the number of commercial fishing businesses currently in operation.

(b) Effects of the Regulation on the Creation of New Businesses or the Elimination of Existing Businesses Within the State:

The Commission does not anticipate any impacts on the creation of new businesses or the elimination of existing businesses within the state. There is no guarantee of a box crab fishery following the completion of the experimental period. If a future fishery is developed, access to or preferential treatment regarding future permits of any type is not implied by participation in the box crab program.

(c) Effects of the Regulation on the Expansion of Businesses Currently Doing Business Within the State:

The Commission does not anticipate any significant impacts on the expansion of businesses currently doing business within the state as the result of the proposed regulations. The intent of the proposed regulations is to allow for a limited use of existing gear types to target box crab pursuant to FGC Section 1022, requiring monitoring and research. While the current incidental take (possession and landing) limit for box crab is no more than 25 pounds (lbs), the proposed regulations provide a process for issuance of EFPs which allows permit holders to take up to 36,000 lbs. annually. This is to provide an adequate allocation of landings for cost recovery. Furthermore, due to the minimal number of permits issued and the limited-term, experimental nature of fishing operations conducted under the EFPs, these permits are not expected to significantly change the level of commercial fishing activities in California or affect the expansion of businesses currently operating in the State.

(d) Benefits of the Regulation to the Health and Welfare of California Residents:

The Commission anticipates indirect benefits to the health and welfare of California residents. Providing opportunities for a potential box crab fishery encourages consumption of a nutritious food.

(e) Benefits of the Regulation to Worker Safety:

The Commission does not anticipate any benefits to worker safety because the proposed regulations would not have any impact on working conditions.

(f) Benefits of the Regulation to the State's Environment:

The Commission anticipates benefits to the State’s environment in the sustainable management of natural resources. It is the policy of the State to ensure the conservation, sustainable use, and where feasible, restoration of California’s marine living resources for the benefit of all the citizens of the state (FGC subdivision 7050(b)). The proposed regulations will allow research into fishing practices that may improve the health, sustainability, and management of the box crab resource and prevent potential future unsustainable harvest.

Informative Digest/Policy Statement Overview

The Department of Fish and Wildlife (Department) is proposing to add new Chapter 5.6, Experimental Fishing Permit (EFP) Program, which will contain new Section 90, Issuance of Experimental Fishing Permits, in Title 14 of the California Code of Regulations (CCR). In addition, a new Section 704, Experimental Fishing Permits; Fees and Forms is proposed to be added to Title 14, CCR, relating to fees and forms associated with issuance of EFPs.

The proposed regulations, implement, in part, Assembly Bill (AB) 1573 (also known as the California Fisheries Innovation Act of 2018) which became effective on January 1, 2019. This legislative action repealed the experimental gear permit (EGP) provisions in Section 8606, Fish and Game Code (FGC), and added new FGC Section 1022, providing for an EFP program to facilitate fishery-related exploration and experimentation to inform fishery management.

Following the repeal of FGC Section 8606, new regulations pursuant to FGC Section 1022 need to be established in Title 14, CCR, to support the continuation of an experimental box crab fishery approved by the Commission in December 2018 before the currently issued EGPs expire on March 31, 2020. The proposed regulations will ensure that current research on a potential box crab fishery can continue while a larger programmatic rulemaking can be developed to build out an EFP program pursuant to FGC 1022.

The proposed regulations will establish a new Chapter 5.6, Experimental Fishing Permit Program, containing new Section 90, Issuance of Experimental Fishing Permits; and additionally, establish new Section 704, Experimental Fishing Permits; Fees and Forms, within Title 14, CCR. The proposed regulations in Chapter 5.6, Section 90, Title 14, CCR will primarily describe the overarching strategy to establish the EFP program and provide a coherent framework in regulations to implement the EFP program.

The proposed regulations in new Section 90, Title 14, CCR will establish the process for issuing EFPs to those applicants previously approved by the Commission in 2018 to receive a box crab EGP. Specifically, Section 90 would allow for the following:

- The Commission may authorize the Department to issue experimental fishing permits to any applicant approved by the Commission in the year 2018 to receive an experimental gear permit pursuant to Fish and Game Code 8606 (repealed, 2018).
- The applicant shall submit a written request for issuance of an EFP at least 60 days prior to the expiration date of their current permit.
- No more than eight valid EFPs will be issued at any one time.
- The Commission may establish Standard Terms applicable to all fishery participants.
- The Commission may approve the adoption, amendment, or repeal of Special Conditions unique to the experimental fishery set forth in form DFW 1085 as it deems necessary for research and the conservation and management of marine resources and the environment.
- The department shall notify a permittee at least 30 days before recommending a change to the Special Conditions of the EFP.
- Access to future permits, if a fishery is developed, is not implied by participation in the EFP program.

The proposed regulations in Section 704 will stipulate the box crab EFP fee pursuant to FGC subdivision 1022(g) that authorizes the Commission to charge a fee as necessary to fully recover, but not exceed, all reasonable implementation and administrative costs of the Department and Commission related to the EFP. The EFP permit fee will be established as $4,487.75.

Section 704 will also incorporate by reference the Experimental Fishing Permit Terms and Conditions Form DFW 1085 (New 08/01/2019), which identifies the person(s) and vessel authorized to conduct activities under the EFP and specifies the Standard Terms and Special Conditions to which EFP permit holders will be subject.

Benefits of the Regulations

It is the policy of the State to ensure the conservation, sustainable use, and, where feasible, restoration of California's marine living resources for the benefit of all the citizens of the state. The objectives of this policy include, but are not limited to, supporting and promoting scientific research on marine ecosystems and their components to develop better information on which to base marine living resource management decisions, and managing marine living resources on the basis of the best available scientific information and other relevant information that the Commission or Department possesses or receives.

The benefit of the proposed regulations will ensure that existing box crab permit holders can continue to collect data for management and test the viability of a box crab fishery, which will inform future management strategies for this emerging fishery.

Consistency and Compatibility with Existing Regulations

The proposed regulations are neither inconsistent nor incompatible with existing State regulations. Section 20, Article IV, of the State Constitution specifies that the Legislature may delegate to the Fish and Game Commission such powers relating to the protection and propagation of fish and game as the Legislature sees fit. The Legislature has delegated to the Commission the power to regulate the review, approval, and issuance of experimental fishing permits that authorize commercial or recreational marine fishing activity that is otherwise prohibited by law (FGC Section 1022). No other State agency has the authority to promulgate experimental fishing permit regulations. The Commission has reviewed its own regulations and finds that the proposed regulations are neither inconsistent nor incompatible with existing State regulations. The Commission has searched the California Code of Regulations for any regulations regarding the review, approval, and issuance of experimental fishing permits and has found no such regulation; therefore, the Commission has concluded that the proposed regulations are neither inconsistent nor incompatible with existing State regulations.

Proposed Regulatory Language

Chapter 5.6, of Subdivision 1. Fish, Amphibians and Reptiles, Title 14, CCR, is added to read:

Chapter 5.6, Experimental Fishing Permit Program.

§Section 90. Issuance of Experimental Fishing Permits.

(a) The commission may authorize the department to issue experimental fishing permits to any applicant approved by the commission in the year 2018 to receive an experimental gear permit pursuant to Fish and Game Code 8606 (repealed, 2018), under the following requirements and restrictions:

(1) Permits will be issued as experimental fishing permits pursuant to Fish and Game Code 1022, and are valid for a term of one year, from April 1, through March 31;

(2) The applicant shall submit a written request to the department for issuance of an experimental fishing permit at least 60 days prior to the expiration date of their current permit.

(3) Upon review and determination by the department that the applicant can meet the standard terms and special conditions of the experimental fishing permit, as set forth in subsection (b):

(A) Experimental fishing permits will be first issued by the department to those applicants who received an experimental gear permit from the department in the year 2018 and submitted a written request for permit issuance pursuant to subsection (a)(2).

(B) Whenever there are less than eight valid permits issued, the department may issue experimental fishing permits to another applicant approved by the commission in 2018 for an experimental gear permit, so long as there are no more than eight valid permits at any one time.

(C) It is unlawful to operate under an experimental fishing permit in violation of the standard terms and special conditions as set forth in subsection (b), or in violation of applicable laws and shall result in immediate suspension or denial of issuance of an experimental fishing permit at the discretion of the department or the commission.

(4) Each year that the experimental fishing permit is issued, the applicant for the experimental fishing permit shall submit the fee, as specified in Section 704, to the department's license and revenue branch. The fee shall be received by the license and revenue branch prior to March 1 of each year, and if the fee is mailed, it must be postmarked prior to March 1.

(b) Permit Standard Terms and Special Conditions

(1) The permittee shall comply with all standard terms set forth in Experimental Fishing Permit Terms and Conditions, form DFW 1085 (subsection 704(a)(2)).

(2) The permittee shall comply with any special conditions approved by the commission and attached to form DFW 1085.

(A) Based upon a recommendation from the department, the commission may approve the adoption, amendment, or repeal of special conditions set forth in form DFW 1085 as it deems necessary for research and the conservation and management of marine resources and the environment.

(B) The department shall notify a permittee at least 30 days before recommending an amendment to the special conditions of the experimental fishing permit.

(c) Access to future permits, if a fishery is developed, is not implied by participation in the experimental fishing permit program.

Note: Authority cited: Section 1022, Fish and Game Code. Reference: Section 1022, Fish and Game Code.

Proposed Regulatory Language

Section 704, Title 14, CCR is added to read:

Section 704. Experimental Fishing Permits; Fees and Forms

(a) Permits/Forms	*Permit Fees (US$)*
(1) Box Crab Experimental Fishing Permit	$4,487.75
(2) Experimental Fishing Permit Terms and Conditions, DFW 1085 (New 08/01/2019), incorporated by reference herein.	

(b) Pursuant to the provisions of Section 699, Title 14, the department shall annually adjust the fees of all licenses, stamps, permits, tags, or other entitlements required by regulations set forth in this section.

Note: Authority cited: Sections 713, 1022, and 1050, Fish and Game Code. Reference: Sections 713, 1022, and 1050, Fish and Game Code.

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations: SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT

DEPARTMENT NAME	CONTACT PERSON	EMAIL ADDRESS	TELEPHONE NUMBER
Fish and Game Commission	Margaret Duncan	margaret.duncan@wildlife.ca.gov	916 653-4674

DESCRIPTIVE TITLE FROM NOTICE REGISTER OR FORM 400	NOTICE FILE NUMBER
Add Ch. 5.6, Section 90; and Add Section 704, Title 14, CCR, Re: Experimental Fishing Permit Program (Phase 1)	Z

A. ESTIMATED PRIVATE SECTOR COST IMPACTS *Include calculations and assumptions in the rulemaking record.*

1. Check the appropriate box(es) below to indicate whether this regulation:

- [X] a. Impacts business and/or employees
- [X] b. Impacts small businesses
- [ ] c. Impacts jobs or occupations
- [ ] d. Impacts California competitiveness
- [ ] e. Imposes reporting requirements
- [ ] f. Imposes prescriptive instead of performance
- [ ] g. Impacts individuals
- [ ] h. None of the above (Explain below):

If any box in Items 1 a through g is checked, complete this Economic Impact Statement.
If box in Item 1.h. is checked, complete the Fiscal Impact Statement as appropriate.

2. The Fish and Game Commission (Agency/Department) estimates that the economic impact of this regulation (which includes the fiscal impact) is:

- [X] Below $10 million
- [ ] Between $10 and $25 million
- [ ] Between $25 and $50 million
- [ ] Over $50 million *[If the economic impact is over $50 million, agencies are required to submit a Standardized Regulatory Impact Assessment as specified in Government Code Section 11346.3(c)]*

3. Enter the total number of businesses impacted: 8

Describe the types of businesses (Include nonprofits): Commercial box crab permit holders

Enter the number or percentage of total businesses impacted that are small businesses: 100%

4. Enter the number of businesses that will be created: 0 eliminated: 0

Explain: 8 permit holders are currently active in this experimental fishery & no more than 8 valid permits will be allowed at any one time

5. Indicate the geographic extent of impacts:
- [ ] Statewide
- [X] Local or regional (List areas): CA marine waters north and south of Point Conception

6. Enter the number of jobs created: 0 and eliminated: 0

Describe the types of jobs or occupations impacted: N/A

7. Will the regulation affect the ability of California businesses to compete with other states by making it more costly to produce goods or services here? [ ] YES [X] NO

If YES, explain briefly:

Instructions and Code Citations:
SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT (CONTINUED)

B. ESTIMATED COSTS *Include calculations and assumptions in the rulemaking record.*

1. What are the total statewide dollar costs that businesses and individuals may incur to comply with this regulation over its lifetime? $ 35,902

   a. Initial costs for a small business: $4,487.75 Annual ongoing costs: $ 4,487.75 Years: 1

   b. Initial costs for a typical business: $4,487.75 Annual ongoing costs: $ 4,487.75 Years: 1

   c. Initial costs for an individual: $N/A Annual ongoing costs: $ N/A Years: 1

   d. Describe other economic costs that may occur: This regulatory action enables the continuation of an existing experimental fishery for eight permit holders.

2. If multiple industries are impacted, enter the share of total costs for each industry: N/A

3. If the regulation imposes reporting requirements, enter the annual costs a typical business may incur to comply with these requirements. *Include the dollar costs to do programming, record keeping, reporting, and other paperwork, whether or not the paperwork must be submitted.* $N/A

4. Will this regulation directly impact housing costs? ☐ YES ☒ NO

   If YES, enter the annual dollar cost per housing unit: $

   Number of units:

5. Are there comparable Federal regulations? ☐ YES ☒ NO

   Explain the need for State regulation given the existence or absence of Federal regulations: Fish and Game Code Section 7090 and Section 1022

   Enter any additional costs to businesses and/or individuals that may be due to State - Federal differences: $ N/A

C. ESTIMATED BENEFITS *Estimation of the dollar value of benefits is not specifically required by rulemaking law, but encouraged.*

1. Briefly summarize the benefits of the regulation, which may include among others, the health and welfare of California residents, worker safety and the State's environment: The proposed regulations will ensure that existing box crab permit holders can continue to collect data to enable the evaluation of the viability of a box crab fishery that will inform future management strategies for this emerging fishery.

2. Are the benefits the result of: ☒ specific statutory requirements, or ☐ goals developed by the agency based on broad statutory authority?

   Explain: CA Assembly Bill (AB) 1573, California Fisheries Innovation Act of 2018 and Fish and Game Code Section 1022

3. What are the total statewide benefits from this regulation over its lifetime? $ 254,826 / year

4. Briefly describe any expansion of businesses currently doing business within the State of California that would result from this regulation: None anticipated

D. ALTERNATIVES TO THE REGULATION *Include calculations and assumptions in the rulemaking record. Estimation of the dollar value of benefits is not specifically required by rulemaking law, but encouraged.*

1. List alternatives considered and describe them below. If no alternatives were considered, explain why not: No alternatives were identified by or brought to the attention of the Commission staff that would have the same desired regulatory effect.

Instructions and Code Citations:
SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT (CONTINUED)

2. Summarize the total statewide costs and benefits from this regulation and each alternative considered:

Regulation: Benefit: $ 254,826 Cost: $ 35,902

Alternative 1: Benefit: $ N/A Cost: $ N/A

Alternative 2: Benefit: $ N/A Cost: $ N/A

3. Briefly discuss any quantification issues that are relevant to a comparison of estimated costs and benefits for this regulation or alternatives: This regulatory action enables the continuation of an existing experimental fishery.

4. Rulemaking law requires agencies to consider performance standards as an alternative, if a regulation mandates the use of specific technologies or equipment, or prescribes specific actions or procedures. Were performance standards considered to lower compliance costs? ☐ YES ☒ NO

Explain: No new technologies or equipment are specified with this regulatory action.

E. MAJOR REGULATIONS *Include calculations and assumptions in the rulemaking record.*

California Environmental Protection Agency (Cal/EPA) boards, offices and departments are required to submit the following (per Health and Safety Code section 57005). Otherwise, skip to E4.

1. Will the estimated costs of this regulation to California business enterprises **exceed $10 million**? ☐ YES ☐ NO

If YES, complete E2. and E3
If NO, skip to E4

2. Briefly describe each alternative, or combination of alternatives, for which a cost-effectiveness analysis was performed:

Alternative 1: ______

Alternative 2: ______

(Attach additional pages for other alternatives)

3. For the regulation, and each alternative just described, enter the estimated total cost and overall cost-effectiveness ratio:

Regulation: Total Cost $ ______ Cost-effectiveness ratio: $ ______

Alternative 1: Total Cost $ ______ Cost-effectiveness ratio: $ ______

Alternative 2: Total Cost $ ______ Cost-effectiveness ratio: $ ______

4. Will the regulation subject to OAL review have an estimated economic impact to business enterprises and individuals located in or doing business in California exceeding $50 million in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through12 months after the major regulation is estimated to be fully implemented?

☐ YES ☒ NO

If YES, agencies are required to submit a Standardized Regulatory Impact Assessment (SRIA) as specified in Government Code Section 11346.3(c) and to include the SRIA in the Initial Statement of Reasons.

5. Briefly describe the following:

The increase or decrease of investment in the State: ______

The incentive for innovation in products, materials or processes: ______

The benefits of the regulations, including, but not limited to, benefits to the health, safety, and welfare of California residents, worker safety, and the state's environment and quality of life, among any other benefits identified by the agency: ______

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations: SAM Section 6601-6616

FISCAL IMPACT STATEMENT

A. FISCAL EFFECT ON LOCAL GOVERNMENT *Indicate appropriate boxes 1 through 6 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year which are reimbursable by the State. (Approximate) (Pursuant to Section 6 of Article XIII B of the California Constitution and Sections 17500 et seq. of the Government Code).

$ ____________

☐ a. Funding provided in ____________

Budget Act of ____________ or Chapter ____________, Statutes of ____________

☐ b. Funding will be requested in the Governor's Budget Act of ____________

Fiscal Year: ____________

☐ 2. Additional expenditures in the current State Fiscal Year which are NOT reimbursable by the State. (Approximate) (Pursuant to Section 6 of Article XIII B of the California Constitution and Sections 17500 et seq. of the Government Code).

$ ____________

Check reason(s) this regulation is not reimbursable and provide the appropriate information:

☐ a. Implements the Federal mandate contained in ____________

☐ b. Implements the court mandate set forth by the ____________ Court.

Case of: ____________ vs. ____________

☐ c. Implements a mandate of the people of this State expressed in their approval of Proposition No. ____________

Date of Election: ____________

☐ d. Issued only in response to a specific request from affected local entity(s).

Local entity(s) affected: ____________

☐ e. Will be fully financed from the fees, revenue, etc. from: ____________

Authorized by Section: ____________ of the ____________ Code;

☐ f. Provides for savings to each affected unit of local government which will, at a minimum, offset any additional costs to each;

☐ g. Creates, eliminates, or changes the penalty for a new crime or infraction contained in ____________

☐ 3. Annual Savings. (approximate)

$ ____________

☐ 4. No additional costs or savings. This regulation makes only technical, non-substantive or clarifying changes to current law regulations.

☒ 5. No fiscal impact exists. This regulation does not affect any local entity or program.

☐ 6. Other. Explain ____________

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations: SAM Section 6601-6616

FISCAL IMPACT STATEMENT (CONTINUED)

B. FISCAL EFFECT ON STATE GOVERNMENT *Indicate appropriate boxes 1 through 4 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year. (Approximate)

$ ______________

It is anticipated that State agencies will:

☐ a. Absorb these additional costs within their existing budgets and resources.

☐ b. Increase the currently authorized budget level for the ______________ Fiscal Year

☐ 2. Savings in the current State Fiscal Year. (Approximate)

$ ______________

☐ 3. No fiscal impact exists. This regulation does not affect any State agency or program.

☒ 4. Other. Explain The establishment of a box crab permit fee of $4,487.75 is anticipated to enable the CA Department of Fish and Wildlife to collect revenue for up to eight permits per year over the next three years. Estimate: $4,487.75 x 8 permits = $35,902 per year X 3 years = $107,706

C. FISCAL EFFECT ON FEDERAL FUNDING OF STATE PROGRAMS *Indicate appropriate boxes 1 through 4 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year. (Approximate)

$ ______________

☐ 2. Savings in the current State Fiscal Year. (Approximate)

$ ______________

☒ 3. No fiscal impact exists. This regulation does not affect any federally funded State agency or program.

☐ 4. Other. Explain ______________

FISCAL OFFICER SIGNATURE | DATE

Original signature on file 7/16/19

The signature attests that the agency has completed the STD. 399 according to the instructions in SAM sections 6601-6616, and understands the impacts of the proposed rulemaking. State boards, offices, or departments not under an Agency Secretary must have the form signed by the highest ranking official in the organization.

AGENCY SECRETARY | DATE

Original signature on file 7/23/19

Finance approval and signature is required when SAM sections 6601-6616 require completion of Fiscal Impact Statement in the STD. 399.

DEPARTMENT OF FINANCE PROGRAM BUDGET MANAGER | DATE

STD. 399 Addendum

Add Chapter 5.6, Section 90; and Add Section 704,
Title 14, California Code of Regulations
Re: Experimental Fishing Permit Program (Phase 1)

Economic Impact Statement

C. Estimated Benefits

Answer 3:

The continuation of the experimental box crab fishery is anticipated to provide approximately $254,826 in total economic output throughout the state marine economy. The state marine economy consists of two industry sectors: 1) fishing operations, transport, and support and; 2) seafood sales, and processing. These sectors include several different marine-related industries: commercial harvesters, seafood processors and dealers, seafood wholesalers and distributors, and retail seafood sales.

The total economic output is derived by first determining the ex-vessel value of the box crab fishery by multiplying the harvest quota of 36,000 pounds times the average market price of $3.97 per pound. The additional value generated from the direct ex-vessel value is estimated with output multipliers to derive the indirect and induced impacts that are summed in the total economic output value.

Output multipliers reflect the incremental re-spending of a specific initial direct expenditure. Direct expenditures are received by supporting businesses who then spend all or a portion of that revenue on additional goods or services. The second-tier business spending is characterized as indirect impacts. Business spending on wages that is received by workers who then spend that income is characterized as induced impacts. Commercial harvest value thus multiplies throughout the economy with the indirect and induced impacts of the initial direct expenditure.

Fiscal Impact Statement

A. Fiscal Effect on Local Government

Answer 5. *No fiscal impact exists. This regulation does not affect any local entity or program.*

B. Fiscal Effect on State Government

Answer 4. Other.

The establishment of a box crab experimental fishing permit (EFP) fee of $4,487.75 is anticipated to enable the California Department of Fish and Wildlife (Department) to collect revenue for up to eight permits per year over the next three fiscal years from 2019/20, 2020/21 and 2021/22.

Department Revenue Estimate: $4,487.75 x 8 permits = $35,902 per year x 3 years = $107,706 Total

Determination of Program Fees.
The Department has a duty to recover all reasonable implementation and administrative costs pursuant to Fish and Game Code subdivisions 1022(g) and 1050(e) (see Table 1). Section 704, Title 14, CCR will stipulate the box crab EFP fee pursuant to Fish and Game Code subdivision 1022(g) that authorizes the Commission to charge a fee as necessary to fully recover, but not exceed, all reasonable implementation and administrative costs of the Department and Commission related to the EFP.

The box crab EFP program is a multi-year research collaboration developed and funded by the Department, California Ocean Protection Council, Resources Legacy Fund, and interested commercial trap fishermen for the purpose of collecting biological information and exploring a new directed fishery for box crab. The Department has estimated the annual reasonable Department costs related with administering and implementing this EFP program, including cost-sharing and participant contributions (Table 1). Several parameters were used to calculate the costs to the Department, including staff time, travel and meetings, and enforcement. Because the Department's Marine Region has management interest in investigating the feasibility of a box crab fishery, some of the cost of developing and managing the box crab EFP program would be shared by the Department by means of excluding the Marine Region's permanent staff time from the overall Department costs as shown in Table 1. The remaining annual cost of the EFP program to be shared by program participants (i.e., permit holders) amounts to $35,902 (for eight box crab permits), which yields a final permit fee of $4,487.75. This permit fee is specified in subsection 704(a)(1), Title 14, CCR of the proposed regulations, and is subject to an annual adjustment pursuant to Fish and Game Code Section 699 (stated in subsection 704(b), Title 14, CCR of the proposed regulations). The proposed regulations are necessary to recover all reasonable implementation and administrative costs relating to the box crab EFP, consistent with Fish and Game Code subdivision 1022(g).

Table 1. Box Crab Permit Fee Determination

Annual Department Costs[1] for 8 Box Crab Permits			
ENFORCEMENT	**Hours**	**Rate ($/hr)**	**Subtotal**
Patrol Vessel	91	$196	**$17,836**
Overhead			$4,337.72
Total			$22,173.72
LICENSE & REVENUE BRANCH (LRB)			
Permit Administration	**Hours**	**Rate ($/hr)**	**Subtotal**
Staff service analyst (SSA)	40	$31.45	$1,258
Program technician (PT)	2	$23.15	$46
Staff services manager (SSMI)	8	$44.64	$357
Staff services manager III (SSMIIII)	4	$54.45	$218
Total Salary/Wages			**$1,879**
Staff Benefits			$991
Subtotal Personnel			**$2,870**
Overhead			$698.03
LRB Total			$3,568
REGION 7 - MARINE	**Hours**	**Rate ($/hr)**	**total costs**
Permanent Staff			
Senior Environmental Scientist (salary + benefits)[2]	1,330	$58.69	$ 78,047
Temporary Staff			
Scientific Aid (Santa Barbara)	145	$15.53	$2,252
Scientific Aid (San Diego)	195	$15.53	$3,028
Temporary Staff Benefits			$2,892
Subtotal Temp Help			**$8,172**
Overhead			$1,988
Temp Help Total			**$10,160**
Total Annual Cost for 8 Permits (less Region 7 permanent staff)			$35,901.99
Cost per Permit[3]			$4,487.75

Sources: California Department of Fish and Wildlife (Department) Law Enforcement, License and Revenue Branch, and Marine Region; 2018-19 California Department of Human Resources salary schedule, 2018-19 Department benefit and overhead rates.

Notes:

1 In addition to Department costs, the box crab EFP program is supported by grants from the California Ocean Protection Council, Resources Legacy Fund, California Sea Grant, and National Oceanic and Atmospheric Administration Saltonstall-Kennedy Grant Program.

2 As the Department's share of the cost, it will not be reimbursed for the Marine Region's permanent staff time to oversee the EFP program through the receipt of the permit fee.

3 The permit fee is an annual cost-share amount for each EFP program participant (i.e., permit holder). The box crab permit fee was derived from the Department costs (minus the Marine Region's salary and benefits for permanent staff) divided by the number of permits approved by the Commission and issued by the Department in December 2018 (i.e., eight permits).

C. Fiscal Effect on Federal Funding of State Programs

Answer 3. *No fiscal impact exists. This regulation does not affect any federally funded State agency or program.*

Experimental Fishing Permit No. __________

EXPERIMENTAL FISHING PERMIT TERMS AND CONDITIONS

Pursuant to California Fish and Game Code (FGC) Section 1022 and Section 90, Title 14, California Code of Regulations (CCR), the Permitholder is authorized to conduct experimental fishing activities according to the authorizations, Standard Terms, Special Conditions and restrictions listed on the Experimental Fishing Permit (EFP) approved by the Fish and Game Commission (Commission) and issued by the California Department of Fish and Wildlife (Department). These Standard Terms shall apply to all persons or vessels conducting activities under an EFP.

Permittee Name: ____________________________

Permittee Address:____________________________

Second Operator Name: ______________________

Second Operator Address: ____________________

Vessel Name and ID # ________________________

Description of Authorized Activity:

STANDARD TERMS

1. An Experimental Fishing Permit number will be provided by the License and Revenue Branch (LRB) for this activity, and it will be valid for a term of one year commencing on _______________and ending on _____________.
2. The permit shall be operated only on the vessel named above. The permittee may designate up to one other permit operator who may also take the authorized species from the vessel named on this permit. Either the primary permittee or the secondary operator must be aboard the vessel, and both are responsible and accountable for meeting the requirements and limits of this permit.
3. Pursuant to FGC Section 7857(d), a valid copy of the original Department issued Automated License Data System permit shall be attached to a signed copy of this form and be on the vessel when activities are being conducted under the authority of this permit.
4. The permittee and any person who assists the permittee, must possess a valid commercial fishing license issued pursuant to FGC Section 7850, prior to engaging in any commercial fishing operations authorized by this permit.
5. The permittee shall possess a valid commercial boat registration issued pursuant to FGC Section 7881, for the vessel named above and display the Department Boat Registration numbers in plain sight on each side of the vessel.

6. The permittee and second operator must comply with all appropriate state and federal laws and regulations, including but not limited to those relating to protected species, minimum size limits, and seasons or areas closed to fishing that are not otherwise exempted by the permit (see special conditions).
7. The permittee and second operator shall cooperate with the Department by allowing personnel designated by the Department to board the fishing vessel operated by the permittee under this permit, to observe or inspect equipment, procedures, or catch, on any fishing trip for as long as the trip may last throughout the duration of the permit.
   a. The vessel must display a current Coast Guard safety decal.
   b. The vessel must be capable of safely carrying an observer and provide that observer with accommodations equivalent to those provided to the captain and crew for both single and multi-day trips if multi-day trips are conducted.

SPECIAL CONDITIONS

Special Conditions for Experimental Fishing Permits may be attached to this permit. The Commission may adopt, amend, or repeal Special Conditions as it deems necessary for research and the conservation and management of marine resources and the environment, as set forth in subsection 90(b)(2)(A), Title 14, CCR.

The permit is not valid until the permittee has certified by their signature below that they have read and understand the Standard Terms and Special Conditions of the permit; paid the fee per Section 704; received a Permit Number; and has returned one signed copy to the Department.

I (we) have read, understand and agree to abide by all Standard Terms and Special Conditions of this permit.

______________________________ ____________

Permittee Signature Date

______________________________ ____________

Second Operator Signature (if applicable) Date

Received by LRB Fee $____________ Experimental Fishing Permit No. __________

____ __________

By: LRB Date

Special Conditions Approved by the Commission

Revision Date: _____________

1. Participants may fish for box crab and rock crab, Dungeness crab or spot prawn within the same trip if appropriate permits for retained species are in place. Adherence to all other regulations regarding the take of these species is required. Brown box crab and lobster shall not be targeted or possessed within the same trip. For research purposes, the Department may provide written authorization for the landing of king crab caught in box crab traps above the 25-pound landing restriction specified in section 126 of Title 14. All other species caught in box crab traps shall be returned to the water immediately and not used as bait.
2. This permit authorizes up to 36,000 pounds of brown box crab to be landed annually by the vessel named in this permit. If this limit is reached prior to one year from the date fishing is initiated, all targeting of box crab must cease until the permit expires and is subsequently renewed.
3. All box crab must have a minimum width of 5 ¾ inches across the widest part of the carapace including spines to be retained, possessed and landed unless authorized in writing by the Department to retain smaller crab for research purposes.
4. No processing or packaging of box crab may take place until weighed, recorded on a landing receipt, and a landing receipt is provided to the permittee by the receiver.
5. Permittees must engage in a minimum of 50 active fishing days per year targeting box crab. Active fishing days include days when box crab traps are pulled and do not include days when only transit or the setting of traps takes place.
6. Pursuant to FGC Section 9004, permittees must service their traps at intervals no more than 96 hours unless otherwise authorized in writing by the Department. Exceptions may be made for weather or other safety concerns.

7.Traps shall meet the following design specifications:

   a. Traps may be any shape but must have a diameter, length or width no larger than 6 feet.
   b. Traps must have at least one round escape port no smaller than 4 inches in diameter.
   c. Traps made of wire mesh must have mesh measurements 1.5 x 3.5 inches or larger.
   d. Escape ports must be in the top or side of the trap. If both are in the side, at least one must be located so that at least one half of the opening is in the upper half of the trap.
   e. Traps must include at least one destruct device to be specified by the Department.
   f. The Department may allow and/or request deployment of specific trap designs for research purposes.

8. Buoy markings shall comply with requirements specified in California Code of Regulations, Title 14, Section 180.5 marking the letter “R” on buoys used for box crab. Additionally, the Department may require a tag of designated shape, color and size, to be provided by the permittee, to be fixed to the line immediately below the buoy.

9. Pop-up buoys shall not be used.
10. A maximum of 75 traps may be fished at one time unless additional traps are authorized in writing by the Department for research purposes.
11. If requested by the Department, permittees must move fishing gear in response to circumstances including, but not limited to, gear conflicts with other fishermen and Naval operations.
12. The permittee shall allow Department designated technicians to install electronic fishery monitoring hardware on their vessel and comply with all associated procedures for operation, maintenance, and data sharing. No fishing for box crab may take place unless a functioning electronic monitoring system is installed and used as specified by the Department. The electronic monitoring must remain active at all times when the vessel is in use through the duration of the project.
13. The permittee shall document all fishing activities using a logbook provided by the Department. Any additional information requested by the Department shall be provided by the permittee. Failure to keep or submit required records of fishing activity may result in revocation or suspension (including non-renewal) of the license or permit for the taking of all fish or the particular species for which the records are required.
14. The permittee shall ensure a landing receipt is submitted using E-Tix within 24 hours following a landing of box crab. Use of E-Tix is described in the California Code of Regulations, Title 14, Section 197.
15. The permittee shall participate in all requested research data collection activities including but not limited to:
    a. Intensive fishing within a designated area.
    b. Trap survey monitoring catch per unit effort with varying levels of trap spacing along strings.
    c. Tag-recapture study.
    d. Crab collections.
    e. Logbook data collection.
16. The permittee must follow the best practices for avoiding whale entanglement described in the attached guide. This includes fishing gear and incident reporting requirements.
17. The permittee and any person who assists the permittee, shall possess a valid general trap permit issued pursuant to FGC Section 9001, prior to engaging in any fishing operations authorized by this permit.
18. Cooperation with domoic acid testing is required by providing samples to the California Department of Public Health when requested.

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
License and Revenue Branch
1740 N. Market Blvd.
Sacramento, CA 95834
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

For background purposes only.

December 20, 2018

EXPERIMENTAL GEAR PERMIT TERMS AND CONDITIONS NUMBER X-####

In accordance with action taken by the California Fish and Game Commission on December 12, 2018, and pursuant to the provisions of Fish and Game Code (FGC) Section 8606, permission is hereby granted to:

Permittee Name: ________________________________
Permittee Address: ________________________________
Second Operator Name: ________________________________
Second Operator Address: ________________________________
Vessel Name and ID # ________________________________

hereinafter called the permittee, to harvest brown box crabs (*Lopholithodes foraminatus*) (box crab) for commercial purposes. This document must be attached to an Experimental Gear Permit (Permit) to be issued by the California Department of Fish and Wildlife's (Department's) License and Revenue Branch (LRB). The gear may only be used under the following conditions:

A. GENERAL TERMS AND CONDITIONS:

1. Pursuant to FGC Section 8606(a)(2), an Experimental Gear Permit number will be provided by LRB for this activity, and it will be valid for a term of one year commencing on April 1, 2019 and ending on March 31, 2020.

2. This permit shall be operated only on the vessel named above. The Permittee may designate up to one other permit operator who may also harvest box crab from the vessel named above. Either the primary permittee or the secondary operator must be aboard the vessel and both are responsible and accountable for meeting the requirements and limits of this permit and all fishing operations conducted under the terms of this permit.

3. Pursuant to FGC Section 7857(d), a copy of the original Department issued Automated License Data Systems license and permit and the signed Terms and Conditions must be on the commercial fishing vessel at all times when activities are being conducted under the authority of this permit.

4. The permittee and any person who assists the permittee, must possess a valid commercial fishing license issued pursuant to FGC Section 7850, prior to engaging in any fishing operations which are authorized by this permit.

5. The permittee and any person who assists the permittee, shall possess a valid general trap permit issued pursuant to FGC Section 9001, prior to engaging in any fishing operations authorized by this permit.

6. The permittee must possess a valid commercial boat registration issued pursuant to FGC Section 7881, for the vessel named above and must display the Department Boat Registration numbers in plain sight on each side of the vessel.

7. The permittee must comply with all appropriate state and federal laws and regulations, including but not limited to those relating to protected species, minimum size limits, and seasons or areas closed to fishing.

8. The permittee shall cooperate with the Department by allowing personnel designated by the Department to board the commercial fishing vessel operated by the permittee under this permit, to observe or inspect equipment, procedures, or fish and crabs on any fishing trip for as long as the trip may last throughout the duration of the permit.
   a. The vessel must display a current Coast Guard safety decal.
   b. The vessel must be capable of safely carrying an observer and provide that observer with accommodations equivalent to those provided to the captain and crew for both single and multi-day trips if multi-day trips are conducted.

SPECIAL CONDITIONS:

1. The permittee must follow the best practices for avoiding whale entanglement described in the attached guide. This includes fishing gear and incident reporting requirements.

2. The permittee shall document all fishing activities using a logbook provided by the Department. Any additional information requested by the Department shall be provided by the permittee. Failure to keep or submit required records of fishing activity may result in revocation or suspension (including non-renewal) of the license or permit for the taking of all fish or the particular species for which the records are required.

3. The permittee shall submit funds in the amount of $4,500 by December 31, 2018 to cover a portion of the Department’s cost for permit approval and monitoring and management of the program.

4. The permittee shall allow Department designated technicians to install electronic fishery monitoring hardware on their vessel and comply with all associated procedures for operation, maintenance, and data sharing. No fishing for box crab may take place unless a functioning electronic monitoring system is installed and used as specified by the Department. The electronic monitoring must remain active at all times when the vessel is in use through the duration of the project.

5. Participants may fish for box crab and rock crab, Dungeness crab or spot prawn within the same trip if appropriate permits for retained species are in place. Adherence to all other regulations regarding the take of these species is required. Brown box crab and lobster shall not be targeted or possessed within the same trip. For research purposes, the Department may provide written authorization for the landing of king crab caught in box crab traps above the 25-pound landing restriction specified in section 126 of Title 14. All other species caught in box crab traps shall be returned to the water immediately and not used as bait.

6. This permit authorizes up to 36,000 pounds of brown box crab to be landed annually by the vessel named in this permit. If this limit is reached prior to one year from the date fishing is initiated, all targeting of box crab must cease until the permit expires and is subsequently renewed.

7. The permittee shall ensure a landing receipt is submitted using E-Tix within 24 hours following a landing of box crab. Use of E-Tix is described in the California Code of Regulations, Title 14, Section 197.

8. The permittee shall participate in all requested research data collection activities including but not limited to:
    a. Intensive fishing within a designated area
    b. Trap survey monitoring catch per unit effort with varying levels of trap spacing along strings
    c. Tag-recapture study
    d. Crab collections
    e. Logbook data collection

9. All box crab must have a minimum with of 5 ¾ inches across the widest part of the carapace including spines to be retained, possessed and landed unless authorized in writing by the Department to retain smaller crab for research purposes.

10. Pursuant to FGC Section 9004, permittees must service their traps at intervals no more than 96 hours unless otherwise authorized in writing by the Department. Exceptions may be made for weather or other safety concerns.

11. Traps shall meet the following design specifications:
    a. Traps may be any shape but must have a diameter, length or width no larger than 6 feet
    b. Traps must have at least one round escape port no smaller than 4 inches in diameter
    c. Traps made of wire mesh must have mesh measurements 1.5 x 3.5 inches or larger.
    d. Escape ports must be in the top or side of the trap. If both are in the side, at least one must be located so that at least one half of the opening is in the upper half of the trap.
    e. Traps must include at least one destruct device to be specified by the Department.
    f. The Department may allow and/or request deployment of specific trap designs for research purposes.

12. Buoy markings shall comply with requirements specified in California Code of Regulations, Title 14, Section 122.1 (b) except the letter “R” will replace the letter “P” on buoys used for box crab. Additionally, the Department may require a tag of designated shape, color and size, to be provided by the permittee, to be fixed to the line immediately below the buoy.

13. Pop-up buoys shall not be used.

14. A maximum of 75 traps may be fished at one time unless additional traps are authorized in writing by the Department for research purposes.

15. Cooperation with domoic acid testing is required by providing samples to the California Department of Public Health when requested.

16. If requested by the Department, permittees must move fishing gear in response to circumstances including, but not limited to, gear conflicts with other fishermen and Naval operations.

17. Permittees must engage in a minimum of 50 active fishing days per year targeting box crab. Active fishing days include days when box crab traps are pulled and do not include days when only transit or the setting of traps takes place.

18. No processing or packaging of box crab may take place until weighed, recorded on a landing receipt, and a landing receipt is provided to the permittee by the receiver.

19. Access to future permits, if a fishery is developed, is not implied by participation in the experimental permit.

Failure to adhere to the terms of the permit or violation of any laws while operating under the permit may result in immediate suspension or denial of renewal request of the box crab experimental gear permit at the discretion of the Department.

This permit is not valid until the permittee has certified by their signature below that they have read and understand the terms of the permit and has returned one signed copy to the Department.

Joshua Morgan, Chief
License and Revenue Branch

I (we) have read, understand and agree to abide by all terms and conditions of this permit

______________________________ ______________
PERMITTEE SIGNATURE **DATE**

______________________________ ______________
SECOND OPERATOR SIGNATURE **DATE**

bc: Melissa Miller-Henson, Acting Executive Director
Fish and Game Commission
Melissa.Miller-Henson@fgc.ca.gov

Craig Shuman, D. Env. Regional Manager
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Julia Coates, Environmental Scientist
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Print Form

DRAFT DOCUMENT

Notice of Exemption

Appendix E

To: Office of Planning and Research
P.O. Box 3044, Room 113
Sacramento, CA 95812-3044

County Clerk
County of: N/A

From: (Public Agency): CA Fish and Game Commission
PO Box 944209
Sacramento, CA 94244-2090
(Address)

Project Title: Add Section 90 and 704, T14, CCR, Experimental Fishing Permit Program (Phase 1)

Project Applicant: N/A

Project Location - Specific:

North and south of Point Conception.

Project Location - City: N/A Project Location - County: N/A

Description of Nature, Purpose and Beneficiaries of Project:
The proposed regulations will bring existing experimental gear permits that were approved by FGC and issued by CDFW in December 2018 pursuant to Fish and Game Code Section 8606 (repealed 2018) into compliance with Fish and Game Code 1022, Experimental Fishing Permit Program.

Name of Public Agency Approving Project: California Fish and Game Commission (FGC)

Name of Person or Agency Carrying Out Project: California Department of Fish and Wildlife (CDFW)

Exempt Status: **(check one):**

- ☐ Ministerial (Sec. 21080(b)(1); 15268);
- ☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
- ☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
- ☒ Categorical Exemption. State type and section number: §15306 & 15307, Title 14, Cal Code Regs
- ☐ Statutory Exemptions. State code number:

Reasons why project is exempt:
The Class 6 exemption is related to CDFW's actions of basic data collection, research, experimental management, and resource evaluation activities; and, Class 7 to assure the maintenance, restoration, or enhancement of a natural resource authorized by statute to protect natural resources and the environment. No exceptions to categorical exemptions apply. See attachment.

Lead Agency
Contact Person: Craig Castleton Area Code/Telephone/Extension: (916) 653-4899

If filed by applicant:

1. Attach certified document of exemption finding.
2. Has a Notice of Exemption been filed by the public agency approving the project?. ☐ Yes ☐ No

Signature: ____________________ Date: __________ Title: Executive Director

☒ Signed by Lead Agency ☐ Signed by Applicant

Authority cited: Sections 21083 and 21110, Public Resources Code.
Reference: Sections 21108, 21152, and 21152.1, Public Resources Code.

Date Received for filing at OPR: __________

Revised 2011

October 10, 2019

ATTACHMENT TO NOTICE OF EXEMPTION
Adoption of Chapter 5.6, Section 90, and Section 704
Title 14, California Code of Regulations (CCR)
RE: Experimental Fishing Permit Program (Phase 1)

The California Fish and Game Commission (Commission) has taken final action under the Fish and Game Code and the Administrative Procedure Act (APA) with respect to the project adopted on October 10, 2019. In taking its final action for the purposes of the California Environmental Quality Act (CEQA, Pub. Resources Code, § 21000 *et seq*.), the Commission adopted Chapter 5.6, Experimental Fishing Permit (EFP) Program, Section 90, Issuance of Experimental Fishing Permits, and Section 704, Experimental Fishing Permits; Fees and Forms, of Title 14, CCR, relying on the categorical exemptions for "Information Collection" and "Actions by Regulatory Agencies for Protection of Natural Resources" contained in CEQA Guidelines sections 15306 and 15307, Title 14, CCR.

In adopting Chapter 5.6, Section 90, and Section 704, Title 14, CCR, the Commission relied, for purposes of CEQA, on the Class 6 exemption related to the California Department of Fish and Wildlife's (Department) actions of basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource; and, the Class 7 exemption to assure the maintenance, restoration, or enhancement of a natural resource where the regulatory process involves procedures for protection of the environment, as set forth in the CEQA Guidelines, sections 15306 and 15307, Title 14, CCR.

The project is part of a study that may lead to future action which the Department has not yet taken.

The proposed regulations implement, in part, Assembly Bill 1573 (Bloom, 2018), also known as the California Fisheries Innovation Act of 2018, which became effective on January 1, 2019. This legislative action repealed the experimental gear permit (EGP) provisions in Fish and Game Code Section 8606 and added new Fish and Game Code Section 1022, providing for an EFP program to facilitate fishery-related exploration and experimentation to inform fishery management. Specifically, the proposed regulations establish the process for issuing the new EFP to the previously approved applicants for box crab EGPs to provide clarity and consistency with Fish and Game Code Section 1022. Because the project involves a process for information gathering for possible future management consideration by the Department and Commission and will not result in significant disturbances to marine resources, the activity is one that is the proper subject of CEQA's Class 6 and Class 7 categorical exemptions.

No exceptions to these categorical exemptions apply.

State of California
Department of Fish and Wildlife

Received July 22, 2019
Original signed copy on file.

Memorandum

Date: July 22, 2019

To: Melissa Miller-Henson
Acting Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Agenda Item for August 8, 2019 Fish and Game Commission Meeting Re: Request for Authorization to Publish Notice of Commission's Intent to Add Chapter 5.6, Experimental Fishing Permit Program, containing Section 90, Issuance of Experimental Fishing Permits; and Add Section 704, Experimental Fishing Permits; Fees and Forms; and Overview of California Environmental Quality Act (CEQA) Categorical Exemptions**

Attached please find the Initial Statement of Reasons (ISOR) which proposes to add a new Chapter 5.6, Experimental Fishing Permit Program, containing new Section 90, Issuance of Experimental Fishing Permits, and add a new Section 704, Experimental Fishing Permits; Fees and Forms, to Title 14, California Code of Regulations (CCR). The proposed regulations will bring existing experimental gear permits (EGPs) for the box crab fishery that were approved by the Fish and Game Commission (Commission) and issued by the Department of Fish and Wildlife (Department) in December 2018 pursuant to Fish and Game Code (FGC) Section 8606 (repealed 2018) into compliance with new FGC Section 1022. A broader programmatic rulemaking (Phase 2, 2020) will be proposed to build out an EFP program as envisioned by the legislature pursuant to Assembly Bill No. 1573 (Bloom, 2018).

The Department requests that the Commission authorize publishing notice of its intent to adopt new Chapter 5.6, containing new Section 90, and adopt new Section 704, Title 14, CCR. Authorization of this request to publish notice will allow for discussion and possible adoption at the October 9-10, 2019 Commission meeting.

The Department asks that the Commission request that the Office of Administrative Law make the regulation effective on or before January 1, 2020.

Categorical Exemptions to Protect Natural Resources and the Environment

This memorandum describes Department staff's analysis of the use of a categorical exemption under the California Environmental Quality Act (CEQA).

The Commission's adoption of the proposed regulations is an action subject to CEQA. The review by Department staff pursuant to CEQA Guidelines Section 15061, Title 14, CCR, led Department staff to conclude that adoption of the

regulations would properly fall within the Class 6 and Class 7 categorical exemptions (CEQA Guidelines Sections 15306 and 15307, Title 14, CCR). The Class 6 exemption is related to the Department's actions of basic data collection, research, experimental management, and resource evaluation activities; and, the Class 7 exemption to assure the maintenance, restoration, or enhancement of a natural resource where the regulatory process involves procedures for protection of the environment.

No Exceptions to Categorical Exemptions Apply

As to the exceptions to categorical exemptions set forth in CEQA Guidelines Section 15300.2, Title 14, CCR, including the prospect of unusual circumstances and related effects, Department staff has reviewed all of the available information possessed by the Department relevant to the issue and does not believe adoption of the regulations poses any unusual circumstances that would constitute an exception to the categorical exemptions set forth above. Compared to the activities that fall within Class 6 and Class 7 generally, which include the given examples of study leading to an action, and wildlife preservation activities of the Department, as the current proposal, there is nothing unusual about the proposed regulations. In addition, even if there were unusual circumstances, no potentially significant effects on either a project-specific or a cumulative basis are expected.

Therefore, the Department does not believe that its reliance on Class 6 and Class 7 categorical exemptions are precluded by the exceptions set forth in CEQA Guidelines Section 15300.2, Title 14, CCR.

If you have any questions or need additional information, please contact Dr. Craig Shuman, Marine Region Regional Manager, at (916) 445-6459. The public notice for this rulemaking should identify Sr. Environmental Scientist Supervisor Tom Mason as the Department's point of contact. Mr. Mason can be reached at (858) 637-7100 or Tom.Mason@wildlife.ca.gov.

Attachments

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Received September 25, 2019
Original signed copy on file.

State of California
Department of Fish and Wildlife

Memorandum

Date: September 23, 2019

To: Melissa Miller-Henson
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Public comment response for proposed adoption of Chapter 5.6, containing Section 90; and proposed adoption of Section 704, Title 14, California Code of Regulations, Re: Experimental Fishing Permit Program (Phase 1) (Agenda Item for the October 9-10, 2019, Fish and Game Commission meeting)**

The Department of Fish and Wildlife (Department) has prepared this memo to inform the proposed adoption of Chapter 5.6, containing Section 90, and proposed adoption of Section 704, Title 14, California Code of Regulations, relating to the issuance of experimental fishing permits (EFPs). There have been no substantive comments received, amendments to the proposed regulatory text, or additional information gathered for this rulemaking.

Public comments received during the period July 25, 2019 through September 23, 2019 are summarized and responded to below.

(1) Chris and Dominique Miller, email received July 25, 2019:

a. The commenters expressed inspiration from the Department's work to date on the box crab EFPs and intend to convene a fisherman's data review committee to discuss approaches to experimental fisheries, beginning with a discussion of whale entanglement and marine mammal conflict resolution.

Department's response:

a. This comment provides general information regarding a process undertaken by stakeholders to encourage experimental fishing activities, which is outside the scope of this rulemaking and therefore does not warrant any changes to the proposed regulations.

(2) Kate Kauer, The Nature Conservancy, oral testimony at August 8, 2019 Fish and Game Commission (Commission) meeting:

a. Supports the Department's recommendation for implementation of the EFP Program through a two-phased approach, and additionally supports the proposed timeline for the EFP Phase 2 rulemaking to allow for additional public scoping.

b. Suggests the Department clarifies the intent of phasing in the EFP Program requirements stipulated in Fish and Game Code (FGC) Section 1022 by amending the regulatory language during the EFP Phase 2 rulemaking; specifically, pertaining to a public comment period, submission of a final report by EFP program participants, and the Commission's flexibility in charging permit fees.

Department's response:

a. Support noted.
b. As discussed in the Initial Statement of Reasons dated July 22, 2019, the Department and Commission will take a two-phased approach to fully implement the EFP Program as required by FGC Section 1022. Phase 1 of EFP Program implementation will produce a process for issuing EFPs for the continuation of the experimental box crab fishery (the intent of this rulemaking). Phase 2 of the EFP Program implementation will fully develop the program as envisioned by the Legislature through FGC Section 1022, and will thus address the concerns raised by the commenter regarding a public comment period, submission of a final report by EFP program participants, and the charging of permit fees. As stated by the Department at the August 8, 2019 Commission meeting, the Department will initiate the Phase 2 rulemaking in 2020.

In conclusion, the Department finds that the comments received do not warrant changes to the proposed experimental fishing permit regulations.

If you have any questions on this item, please contact Dr. Craig Shuman, Regional Manager of the Marine Region, at (916) 445-6459 or Craig.Shuman@wildlife.ca.gov.

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Experimental Fishing Permit Rulemaking

Fish and Game Commission Meeting

October 10, 2019

Adoption Hearing

Dr. Craig Shuman
Marine Regional Manager
California Department of Fish and Wildlife

Background

- Assembly Bill 1573 (2018) – Repealed FGC Section 8606 experimental gear permits and added new FGC Section 1022
- FGC Section 1022 – Requires the Commission to establish an Experimental Fishing Permit (EFP) program to facilitate fishery-related exploration and experimentation to inform fishery management

EFP Program Phase I

Phase I: Regulatory framework for the box crab program to continue under FGC Section 1022 before existing permits expire in March 2020.

Key components of proposed regulations:

- Establishes a process for issuance of box crab EFPs
- Establishes a form for permit terms and conditions
- Sets a permit fee

Timeline:	August 2019	Notice
	October 2019	**Discussion and adoption**
	January 2020	Effective date

EFP Program Phase II

Phase II: Build out of EFP program in 2020.

Timeline:	January 2020	Public scoping to receive input
	March	Provide update at MRC meeting
	August	Notice
	October	Discussion
	December	Adoption hearing

Thank You

For more information please contact:

Tom Mason

Sr. Environmental Scientist

Marine Region, Department of Fish and Wildlife

Tom.Mason@Wildlife.ca.gov

STAFF SUMMARY FOR JUNE 12-13, 2019

25. PACIFIC HERRING FISHERY MANAGEMENT PLAN (FMP)

Today's Item **Information ☐** **Action ☒**

Receive and discuss the draft Pacific herring FMP and California Environmental Quality Act (CEQA) documentation.

Summary of Previous/Future Actions

- DFW updates on FMP progress — 2016-2017; MRC meetings
- DFW update and MRC recommendation — Jul 17, 2018; MRC, San Clemente
- FGC endorses MRC recommendation — Aug 22-23, 2018; Fortuna
- Update on FMP progress — Mar 20, 2019; MRC, Sacramento
- **Today receive draft FMP** — **Jun 12-13, 2019; Redding**
- Discuss draft FMP — Aug 7-8, 2019; Sacramento
- Potentially adopt CEQA document and FMP — Oct 9-10, 2019; San Diego

Background

The Marine Life Management Act (MLMA) requires that fishery management plans (FMPs) form the primary basis for managing California's marine fisheries (Section 7072 et seq., Fish and Game Code). Pursuant to the mandates of MLMA, DFW has been developing the California Pacific herring FMP (Herring FMP) since 2016 with a collaborative working group of herring fleet leaders, staff from conservation non-governmental organizations, and DFW. In Aug 2018, FGC approved an MRC recommendation to support the DFW-proposed schedule for receipt of the Herring FMP and proposed implementing regulations, following independent scientific peer review.

In Dec 2018, DFW notified FGC that a change in the FMP and rulemaking timetable was necessary to allow DFW time to address specific recommendations from the FMP peer review, and in Feb 2019, DFW proposed Jun 2019 for the start of the new timeline. In granting this request, FGC asked that an update on the draft Herring FMP content and the commercial fishery be provided at the Mar 2019 MRC meeting prior to receipt in Jun.

MLMA requires that FGC hold at least two public hearings prior to FMP adoption. However, at the request of DFW, a three-meeting process for the Herring FMP is being undertaken to allow adequate time for public review. Written comments may be submitted at any time up to adoption. FGC may either adopt the FMP or, if it determines changes are warranted, may reject the FMP for DFW to revise and resubmit for further public review before adoption.

The draft Herring FMP and DFW transmittal memo are provided in exhibits 1 and 2. The Herring FMP and proposed implementing regulations (under Agenda Item 26, this meeting) have been prepared by DFW based on input from the collaborative working group and independent, external peer review, and have also benefited from input from FGC, MRC, California tribes, and stakeholders.

The Herring FMP fulfills FGC's obligation to comply with CEQA in considering and adopting an FMP and associated implementing regulations; if approved, a 45-day public comment period will commence with the Jun FGC meeting and close Jul 29 (Exhibit 3).

At today's meeting, DFW will provide an overview of the draft Herring FMP (Exhibit 4).

Significant Public Comments (N/A)

Recommendation

FGC staff: Receive the draft FMP and direct staff to publish notice of FGC intent to adopt the FMP and commence the public comment period.

DFW: Receive FMP at Jun 12-13, 2019 FGC meeting and open a 45-day public comment period through Jul 29 for CEQA review.

Exhibits

1. DFW transmittal memo, received May 22, 2019
2. Draft *California Pacific Herring Fishery Management Plan*, dated May 15, 2019
3. DFW transmittal memo, Notice of Completion and Notice of Availability for Public Comment, received May 24, 2019
4. DFW presentation

Motion/Direction (N/A)

Moved by __________ and seconded by __________ that the Commission directs staff to publish notice of its intent to adopt a fishery management plan for California Pacific herring.

STATE OF CALIFORNIA

FISH AND GAME COMMISSION
MEMORANDUM

DATE: September 12, 2019

TO: Senator Mike McGuire, Chair
Assembly Member Mark Stone, Vice Chair
Joint Committee on Fisheries and Aquaculture
California State Legislature

FROM: Melissa Miller-Henson, Executive Director

SUBJECT: Fishery management plan for California Pacific herring scheduled for adoption

To guide future sustainable management of the pacific herring fishery in California, a fishery management plan (FMP) has been under development by the California Department of Fish and Wildlife (DFW) since 2016. FMPs form the primary basis for managing California's sport and commercial marine fisheries (Section 7072 et seq., California Fish and Game Code) as well as the framework through which implementing regulations are adopted by the California Fish and Game Commission (Commission).

Pacific herring, an important forage species in California and along the West Coast, is harvested commercially as a roe fishery and managed through Commission regulations that establish fishing quotas based on herring spawning population size. Developed by a cross-interest steering committee, the Pacific herring FMP establishes a new harvest control rule, integrates ecosystem considerations, revises the existing commercial limited entry permit system and related fishing regulations, and identifies regulations for the recreational herring fishery.

During FMP development, regular updates were presented to the Commission's Marine Resources Committee and the Commission; after public vetting and discussion, the committee recommended that the Commission support the FMP.

Following scientific peer review, the draft FMP and proposed regulations necessary to implement the plan were received by the Commission in June 2019. In August 2019, the Commission received a revised FMP and held a discussion hearing. Adoption of the FMP and associated regulatory changes intended to implement the FMP are expected in October 2019, with the goal of having regulations in place for the 2020-2021 fishing season.

California Fish and Game Code Section 7078(d) requires that, prior to adopting an FMP or plan amendment that would make a statute inoperative, the Commission provide a copy to the California State Legislature for review by the Joint Committee on Fisheries and Aquaculture, or the appropriate policy committee in each house. Therefore, the Commission is providing you a copy of the draft final Pacific herring FMP. Due to its size, the electronic file cannot be sent via email; however, it is available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=172866&inline.

Listed in Table 1 are those statutes that will become inoperative upon the Commission's adoption of the FMP, pursuant to Fish and Game Code Section 7088 (also included in Section 9 of the FMP).

Questions regarding the Commission adoption process can be directed to Susan Ashcraft, Acting Deputy Executive Director, at (916) 653-1803 or Susan.Ashcraft@fgc.ca.gov.

Table 1. Statutes made inoperative by the adoption of the California Pacific Herring FMP

Fish and Game Code Section	Topic	Superseded by Proposed Regulation Subsections
8389	Herring Eggs; Authority to prescribe regulations, permits, royalty fee, and limits, incidental take, herring-eggs-on-kelp (HEOK)	55.02(a), (d), and (e); 163(b) and (c); 164(a) and (b); 705(a)
8550	Fish and Game Commission (Commission) regulates herring, number of permits, amount of take per permit	55.02(a), (d), and (e)
8550.5	Herring net permit fee	163(a) and (b), 705(a)
8552	Herring Roe permit conditions	163(a), (b), and (h)
8552.2	Herring permit transferability - experience points	163(b), (h)
8552.3	Commission regulates permit transfers	55.02(e); 163(b), (c), and (h)
8552.4	Department to hold drawing for revoked permits - experience points	163(b) and (d)
8552.5	Commission may revoke herring permits	55.02(e), 163(g)
8552.6	Herring permit ownership	163(c), (h), and (e)
8552.7	Transfer fee is $5000	705(b)
8552.8	Experience points – permit sales and transfers	163(d) and (h)
8553	Commission regulates herring	55.02(d), 55.02(e)
8554	Commission may regulate temporary substitution of permittee	163(e)
8556	Commission regulates take by gill net and mesh size	55.02(e), 163.1(c)
8557	Commission regulates herring take by round net	55.02(b), 163.1(c)
8558	Herring Research Account	163(b), (c), and (d), 705(a)
8558.1	Herring Stamp and Fee	163(b), (c), and (d), 705(a)

8558.2	Difference between resident and non-resident fees to be deposited in Herring Research Account	163(b), (c), and (d), 705(a)
8558.3	1/2 of herring roe fees goes to research	163(b), (c), and (d); 705(a)
8559	Commission shall set experience requirements	163(c), (d), and (h); 705(a)

ec: Tom Weseloh, Chief Consultant, Joint Committee on Fisheries and Aquaculture,
California State Legislature, Tom.Weseloh@sen.ca.gov
California Department of Fish and Wildlife
Charlton Bonham, Director, Director@wildlife.ca.gov
Clark Blanchard, Acting Deputy Director for Legislative Affairs,
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Craig Shuman, Regional Manager, Marine Region,
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Executive Summary

Pacific Herring (Herring), *Clupea pallasii*, support an important and historically significant commercial fishery in California. Four areas within the state have spawning stocks large enough to enable a fishery, including San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City; however, over 90% of landings come from San Francisco Bay. Commercially, Herring are targeted for roe products, bait, and fresh fish. Since its onset in the winter of 1972, the sac-roe fishery (the eggs from gravid female Herring), has dominated landings, while landings in the whole fish sector are minor. A recreational Herring fishery also has taken place since at least the 1970s. The primary market for California's commercial Herring fishery is Japan, where Herring roe is considered a delicacy. Herring are also used as bait for salmon, *Oncorhynchus* spp., Pacific Halibut, *Hippoglossus stenolepis*, and Lingcod, *Ophiodon elongatus*, by recreational anglers. Herring may also be smoked, pickled or canned for personal consumption.

The roe fishery was one of the most commercially valuable in California, reaching landings of more than 12,000 tons and an ex-vessel value of almost $20 million, but has since declined due to lower demand and competition from other Herring fisheries outside of California. Given the initial high value of sac-roe, high participation levels (more than 400 permits at its peak), and limited space in the San Francisco Bay, the Herring fishery benefitted from an intensive level of management.

Regulations changed annually as the fishery expanded, and many regulations were designed to address socioeconomic rather than biological issues. Primary management measures used historically include but are not limited to limited entry, permits issued by lottery, individual vessel quotas, quota allocation by gear, a platoon system used to divide gill net vessels into groups, the transferability of fishery permits, and the conversion of permits between gear types. However, as the price and participation has continued to decline, particularly since the early 2000s, many of the regulations developed to manage a much larger fleet are outdated and no longer necessary. Additionally, despite concerns about an increasing level of take and potential for commercialization among the recreational Herring fishery, no restrictions on catch or effort for this sector have been established.

There were concerns about declining stock sizes in the late 1990s and early 2000s, and in response the Department began using more precautionary quota setting procedures. One of the primary goals of this Fishery Management Plan (FMP) was to further develop and codify this precautionary approach to ensure the sustainable management of California Herring into the future. In addition, Herring not only support commercial and recreational fisheries, but as forage fish they are a food source for many predatory fish, marine mammals, and seabirds within the California Current Ecosystem (CCE), providing an essential energetic link between primary producers and predators at the top of food chains. As such, a secondary goal was to develop a management approach that complies with the California Fish and Game Commission's (Commission) forage species policy, which seeks to recognize the importance of forage fish to the ecosystem and establishes goals intended to provide adequate protection to these species.

The overarching goal of this FMP is to ensure the long-term sustainable management of the Herring resource consistent with the requirements of the Marine Life Management Act (MLMA) and the Commission's forage species policy. In particular, it seeks to:

- provide a synthesis of relevant information on the species, its habitat, role in the ecosystem, and the fishery that targets it,
- integrate the perspectives and expertise of industry members and other stakeholders in the management process,
- describe the effects of climate change on California's Herring stocks, and identify environmental and ecosystem indicators that can inform effective management,
- provide an adaptive management framework that can detect and respond to changing levels of abundance and environmental conditions,
- specify criteria for identifying when a fishery is overfished,
- streamline the annual quota-setting process while ensuring that it is based on sound science,
- create an orderly fishery through an efficient permitting system,
- ensure that research efforts are strategic and targeted,
- use collaborative fisheries research to help fill data gaps,
- identify risks and minimize threats to habitat from fishing, and
- minimize bycatch to the extent practicable.

The MLMA requires that management changes be based on both the best available science as well as stakeholder input. Beginning in 2012, a Steering Committee (SC) including Herring fleet leaders, representatives from conservation non-governmental organizations (NGOs) and California Department of Fish and Wildlife (Department) staff evolved to develop a vision for the Herring FMP. This SC provided guidance throughout the FMP process and communicated the goals and strategies of the plan to their wider communities. In 2016 when the FMP development process was formally initiated, the scope of the FMP was presented to the California Fish and Game Commission (Commission) and refined via a public comment process. California Native American Tribes also were consulted. Permit holders were surveyed to gain input regarding potential regulatory changes. After the management strategy was developed, it was presented to the Commission and through other public meetings (both web-based and in-person) for stakeholder feedback.

Throughout the Herring FMP process, a number of scientific analyses, including a Management Strategy Evaluation (MSE) to develop and test a Harvest Control Rule (HCR), an analysis of correlations between Herring productivity and environmental indicators, and a meta-analysis of dietary studies to better understand predator-prey relationships were conducted to ensure that the proposed management strategy had a solid scientific foundation. The management strategy was further refined based on the feedback of an external, independent peer review committee. While the Herring fishery is relatively data rich, a number of informational gaps were highlighted during this process, specifically related to the relationship between Herring, predator populations in the CCE, and alternative prey species. Additional information in these areas would allow the Department to more fully consider ecosystem impacts in future Herring management.

Management Strategy

This FMP proposes a management strategy that is based on an adaptive management framework that seeks to improve management of Herring in California through monitoring and evaluation, in order to better understand the interaction of different elements within marine systems. The management strategy consists of procedures to: 1) monitor Herring populations in the four management areas (San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor), 2) analyze the data collected via the monitoring protocol to estimate Spawning Stock Biomass (SSB), 3) develop quotas based on current SSB using a HCR, 4) track indicators to monitor ecosystem conditions and adjust quotas as needed, and 5) additional management measures to regulate fishing.

The primary mechanism for ensuring stock sustainability in California's Herring management areas is to restrict harvest to a rate of no more than 10% of the estimated SSB by setting catch limits (quotas). This cap on the target harvest rate was agreed upon by a group of representatives from the fishing industry and conservation NGOs prior to beginning the development of this FMP as a means of continuing the precautionary management approach the Department has employed since 2004. Additional management measures are in place to ensure that harvest primarily targets age 4+ fish (mesh size restrictions), that spawning aggregations receive some temporal and spatial refuges from fishing (closed areas and weekend closures), and to minimize interactions between fishermen and concurrent users of the four management areas.

Tiered Management Approach

Implementing intensive surveys, like the annual spawn deposition surveys used to estimate the SSB in San Francisco Bay, in all four management areas is not feasible due to resource and staffing constraints. Thus, this FMP outlines a three-tiered management approach to help prioritize monitoring efforts and apply appropriate levels of management to fit the fishery activity level. Using this approach, each management area falls into one of three tiers based on the level of fishing occurring. Tier 3 has the highest level of fishing activity, Tier 2 is intermediate, and Tier 1 has the lowest level of fishing activity. The level of monitoring effort associated with each tier is dictated by the level of participation in the fishery. Quotas are determined based on the information available. As more information is available, higher harvest rates are available to participants, provided stock sizes can sustainably support higher levels of catch. When this FMP was first drafted, Tomales Bay, Humboldt Bay, and Crescent City Harbor were Tier 1 management areas, and the San Francisco Bay was the only Tier 3 management area.

Multi-Indicator Predictive Model to Estimate SSB

Setting quotas in Tier 3 management areas requires an estimate of the expected total SSB in the coming season in order to set a quota that will achieve the desired harvest rate. As part of the FMP development process, information on correlations between biological indicators of Herring stock health and environmental indicators were used to develop a predictive model to estimate the coming year's SSB. Although ecological indicators have been assessed yearly and presented as part of the annual season summary to the Director's Herring Advisory Committee (DHAC) for management recommendations and to provide context for the SSB estimate, they have not been used to quantitatively predict the SSB to set quotas prior to this FMP. The multi-indicator predictive model includes the following three indicators:

1. SSB_{year-1} – the observed spawn deposition from the previous season
2. YOY_{year-3} – the Catch Per Unit Effort (CPUE) of Young of the Year (YOY) Herring from April to October three years prior
3. $SST_{Jul-Sep}$ – The average Sea Surface Temperate (SST) between July and September prior to the upcoming season

The above-described model explains more variability, mechanistically supports what is known about Herring stocks, and reduces predictive error when compared to the current method. The synthesis of different environmental and ecosystem data into a multivariate forecasting equation may promote proactive, rather than reactive, management, and foster an interdisciplinary approach to ecosystem-based fisheries management. The FMP adopts this multi-indicator predictive model as an option for estimating the coming season's SSB in San Francisco Bay, contingent upon availability of necessary input data and continued predictive power by the model. Spawn deposition surveys remain the default method for determining SSB.

Harvest Control Rule

A key provision of this FMP is a HCR for California's Herring fishery to ensure that quotas are appropriate given the current SSB, and that intended harvest percentages (target harvest rates) are no more than 10 percent (%). The HCR developed for San Francisco Bay includes a SSB cutoff at 15,000 tons, below which no fishing can occur and the quota for the coming season will be zero.

Developed in consultation with Department staff and stakeholders and tested using MSE, the HCR is used to set appropriate quotas in Tier 3 management areas. The HCR developed is based on the current precautionary management approach and provides a predetermined method for setting initial quotas each year based on SSB estimates.

<u>Assessing Ecosystem Indicators</u>

Given Herring's role as a forage species in the CCE, one of the primary goals of this FMP was to develop a transparent procedure for incorporating ecosystem considerations into Herring management. A set of ecosystem indicators was selected based on scientific analysis to provide a holistic view of predator-prey conditions in the system. These indicators are arranged in a decision tree to assist Department staff in determining whether additional quota adjustments are warranted. Additional environmental indicators were also chosen to provide information on the general health and productivity of the CCE, ensuring that decisions about the Herring stock are placed in the context of the larger ecosystem. The status of these additional indicators will be periodically described in an Enhanced Status Report.

<u>Additional Management Measures</u>

Existing management measures were evaluated during the FMP development process to ensure alignment with the overall management strategy proposed for California's Herring fishery. At this time, no changes are recommended for restrictions on catch, areas open to fishing, size, sex, or gear. Existing management measures to reduce impacts to habitat, as well as bycatch and discards were also found satisfactory.

Based on stakeholder input, this FMP institutes a single start (02 January) and end date (15 March) for all four management areas, compared to previously each had their own season dates.

<u>Changes to streamline and modernize the regulations</u>

The FMP development process provided an opportunity to modify existing Herring regulations for the gill net, Herring Eggs on Kelp (HEOK), and recreational fisheries. The goal of these changes was to meet the needs and capacity of the modern fleet, standardize and clarify the regulatory language across sectors and areas, and to make the regulations consistent with those used in other fisheries in California.

Gill net Fishery – The platoon system, and the complex permitting associated with that system, was developed for a much larger fleet and is no longer necessary in San Francisco Bay. To modernize the Herring gill net fishery regulations, the following regulatory changes will be made:

- convert all permit types to a single permit that allows holders to fish every week of the season in order to eliminate the platoon system in San Francisco Bay,
- establish a long-term capacity goal of 30 permits under the new permitting system,
- eliminate the paperwork associated with substitution by allowing anyone who possesses a valid California Commercial Fishing License to operate a Herring fishing vessel provided the permit is onboard and that vessel has been designated,
- require that gill nets be marked with the Fishing Vessel Number designated on the permit to track fishing activities,
- remove yearly quota specification from regulations, and instead set quotas via the HCR under the authority of the Director of the Department,
- reduce the permit cap from 35 to 15 in Tomales Bay,
- establish new conservative quotas for Tier 1 and 2 fisheries,
- adjust regulations to promote collaborative research between the Department and the fishing industry, and
- alter and update the permitting process.

HEOK – To streamline the HEOK fishery sector, the following regulations changes were determined via the FMP development process:

- restructure the permitting process such that HEOK permits are completely separate from the gill net permits,
- bring HEOK fees in line with those paid by the gill net sector,
- streamline notification requirements,
- require vessels, rafts and lines to display the Fishing Vessel Number designated on the permit to track fishing activities,
- require cork lines to be marked at each end with a contrasting-colored buoy for easier maneuverability.

Recreational Regulations – Prior to this FMP, there was no limit for the recreational take of Herring. To address this, the FMP recommends a range between 0 and 100 pounds, which is equivalent to up to 10 gallons (or two 5-gallon buckets), as a daily bag limit. This established bag limit is easily enforceable and provides for a satisfying recreational experience while deterring illegal commercialization of the fishery.

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List of Acronyms

APA	Administrative Procedure Act
BL	Body length
CCE	California Current Ecosystem
CCIEA	California Current Integrated Ecosystem Assessment
CCR	California Code of Regulations
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CDFW	California Department of Fish and Wildlife
CI	Condition Index
Commission	California Fish and Game Commission
CPUE	Catch per Unit Effort
CRFS	California Recreational Fisheries Survey
DED	Draft Environmental Document
Department	Department of Fish and Wildlife
DHAC	Director's Herring Advisory Committee
ED	Environmental Document
EFI	Essential Fishery Information
EIR	Environmental Impact Report
ENSO	El Niño Southern Oscillation cycle
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Units
FED	Final Environmental Document
FGC	Fish and Game Code
FMP	Fishery Management Plan
GOF	Gulf of the Farallones
HEOK	Herring Eggs on Kelp
HCR	Harvest Control Rule
Legislature	California State Legislature
LTMS	Long Term Management Strategy
M	Mortality, often reported as an instantaneous natural mortality
MEI	Multivariate ENSO Index
MLMA	Marine Life Management Act
MLLW	Mean Lower Low Water
MOCI	Multivariate Ocean Climate Indicators
MSE	Management Strategy Evaluation
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
NOP	Notice of Preparation
NPGO	North Pacific Gyre Oscillation
PAHs	poly-aromatic hydrocarbons
PDO	Pacific Decadal Oscillation

PRC	Public Resources Code
SFBHRA	San Francisco Bay Herring Research Association
SSB	Spawning Stock Biomass
SST	Sea Surface Temperature
YOY	Young of the Year

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Acknowledgements

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Chapter 1. Introduction

The Marine Life Management Act (MLMA) is California's primary fisheries management law. It directs the Department of Fish and Wildlife (Department) to ensure the sustainable use of the state's living marine resources (Fish and Game Code [FGC] §7050(b)). The MLMA also identifies Fishery Management Plans (FMPs) as the primary tool for achieving this goal (FGC §7072). FMPs are comprehensive planning documents that outline what is known about a species, the characteristics and impacts of the fishery that targets it, and how that fishery is to be managed and monitored once the FMP is implemented. The Department is responsible for drafting FMPs and presenting them to the California Fish and Game Commission (Commission) for adoption. New regulations required to implement a FMP are promulgated through a separate Commission rulemaking process, and are codified in Title 14 of the California Code of Regulations (CCR).

This FMP for Pacific Herring (Herring), *Clupea pallasii*, was first presented to the Commission in June 2019 and was adopted in October of 2019. Its goals, development process, and contents are described below.

1.1 Goal and Principal Strategies

Herring have supported commercial and recreational fisheries in California for more than one hundred years. They are also an important forage species in the California Current Ecosystem (CCE). The overarching goal of this FMP is to promote the long-term sustainable management of the Herring resource consistent with the requirements of the MLMA and the Commission's policy on forage fish. In particular, it seeks to:

- provide a synthesis of relevant information on the species, its habitat, role in the ecosystem, and the fishery that targets it;
- integrate the perspectives and expertise of industry members and other stakeholders in the management process;
- identify environmental and ecosystem indicators that can inform management;
- provide an adaptive management framework that can quickly detect and respond to changing levels of abundance and environmental conditions;
- specify criteria for identifying when a fishery is overfished;
- streamline the annual quota-setting process while ensuring that it is based on sound science;
- create an orderly fishery through an efficient permitting system;
- ensure that research efforts are strategic and targeted;
- use collaborative fisheries research to help fill data gaps;
- identify risks and minimize threats to habitat from fishing; and
- minimize bycatch to the extent practicable.

Specific strategies for achieving these goals are identified and described in the relevant chapters of the FMP.

1.2 Collaborative Development Process

A barrier often facing FMP development in California has been the significant financial and staff resources required for their preparation. These resource constraints have translated to relatively few FMPs being developed since the MLMA was enacted in 1999. To help overcome this challenge, beginning in 2012, Herring fleet leaders, representatives from conservation non-governmental organizations (NGOs), and Department staff began a discussion group to develop a vision for a Herring FMP. Through regular meetings over a four-year period, the discussion group identified a new, more collaborative approach to FMP development that preserved Department control while utilizing outside resources and expertise. The resulting process for FMP development is intended to be used as a test case and a potential model for future FMPs for other fisheries.

The MLMA places great emphasis on constituent involvement in decisions regarding marine resources, as well as collaboration among stakeholders. This Herring FMP has sought to incorporate stakeholder feedback throughout its development process and has done so in a number of ways. Prior to initiation of the Herring FMP, the discussion group worked to develop a “blueprint” outlining the broad scope and goals for the FMP development process, as well as the scientific analyses required to meet those goals. Industry and conservation stakeholders agreed to a broad outline for a Harvest Control Rule (HCR) to set yearly quotas, namely, that it would emulate the Department’s precautionary management approach by capping target harvest rates at 10 percent (%) of the most recently estimated biomass, and include ecosystem indicators to further inform management. This agreement helped to reduce conflict between stakeholder groups and helped to focus scientific efforts. The discussion group evolved into a more formalized Steering Committee (SC) in 2016. The SC provided feedback and guidance throughout the FMP development process, and helped communicate the goals, objectives, and strategies of the FMP to their wider constituencies. Results of research conducted as part of FMP development were also shared with the SC iteratively throughout the process, and as a result the management strategy in this FMP reflects both the best available science as well as a high degree of stakeholder involvement.

Once the FMP development process was formally initiated in April of 2016, the scope of the FMP was presented to the Commission, and was further refined via the public scoping process, as well as through Tribal consultation. In addition, a survey of all Herring permit holders was conducted to understand the desire and need for regulatory changes, and the results of this survey were used to develop regulatory proposals. Once a management strategy was developed, it was presented to the Commission through the Marine Resources Committee. It was also presented at other public meetings (both web-based and in-person), and feedback from stakeholders was solicited and incorporated.

1.3 Fishery Management Plan Contents

Sections 7080-7088 of the MLMA describe in detail the required contents of FMPs and the Department's 2018 Master Plan for Fisheries includes guidance regarding how specific issues should be addressed. The structure and content of this FMP are based on the direction they provide.

The FMP first provides an overview of what is known about the natural history of the species and its role in the ecosystem (Chapters 1-3). It then describes the Herring fishery and the history of its management and monitoring (Chapters 4-6). The core of the FMP is Chapter 7, which outlines an integrated approach to monitoring, assessment, and management of the fishery moving forward. Chapter 7 includes a discussion of measures to promote sustainability of the stock and management of bycatch and habitat impacts. The FMP includes a chapter on alternative projects considered during FMP development. The FMP also includes a chapter focused on future research and management needs (Chapter 8), a chapter that describes what actions can be taken through rulemaking under the FMP and those that require a FMP amendment (Chapter 9), a chapter that includes an analysis of alternative management actions (Chapter 10) and a final chapter that includes literature cited (Chapter 11). The appendices provide additional detail on the FMP's development history, monitoring efforts, and modeling approaches and outcomes (Appendices A-P). Under Section 7088 of the MLMA, FMPs have the ability to render conflicting statutory law inoperative once adopted by the Commission. The FMP contains a list of these conflicting statutory provisions that will be made inoperative in Chapter 9.

1.4 Environmental Document under the California Fish and Game Commission's Certified Regulatory Program

This document is also intended to fulfill the Commission's obligation to comply with the California Environmental Quality Act (CEQA) [Public Resources Code (PRC) §21000 et seq.] in considering and adopting an FMP, and associated implementing regulations. In general, public agencies in California must comply with CEQA whenever they propose to approve or carry out a discretionary project that may have a potentially significant adverse impact on the environment. Where approval of such a project may result in such an impact, CEQA generally requires the lead public agency to prepare an Environmental Impact Report (EIR). In contrast, where no potentially significant impacts could result with project approval, a lead agency may prepare what is commonly known as a negative declaration. Where an EIR is required, however, the document must identify all reasonably foreseeable, potentially significant, adverse environmental impacts that may result from approval of the proposed project, as well as potentially feasible mitigation measures and alternatives to reduce or avoid such impacts. Because the lead agency must also subject the EIR to public review and comment, and because the agency must respond in writing to any public comments raising significant environmental issues, compliance with CEQA serves to protect the environment and to foster informed public decision-making.

CEQA also provides an alternative to preparation of an EIR or negative declaration in limited circumstances. Under CEQA, the Secretary of Resources is authorized to certify that a state regulatory program meeting certain environmental standards provides a functionally equivalent environmental review to that required by CEQA [PRC §21080.5; see also CEQA Guidelines, CCR Title 14 §15250- 15253]. As noted by the California Supreme Court, "[c]ertain state agencies, operating under their own regulatory programs, generate a plan or other environmental review document that serves as the functional equivalent of an EIR. Because the plan or document is generally narrower in scope than an EIR, environmental review can be completed more expeditiously. To qualify, the agency's regulatory program must be certified by the Secretary of the Resources Agency. An agency operating pursuant to a certified regulatory program must comply with all of CEQA's other requirements" [*Mountain Lion Foundation v. Fish and Game Comm.* (1997) 16 Cal.4th 105, 113-114 (internal citations omitted)].

The Commission's CEQA compliance with respect to the Herring FMP and associated regulations is governed by a certified regulatory program [CEQA Guidelines, CCR Title 14 §15251, subd. (b)]. The specific requirements of the program are set forth in CCR Title 14 in the section governing the Commission's adoption of new or amended regulations, as recommended by the Department (CCR Title 14 §781.5). Pursuant to CCR Title 14 §781.5, this Environmental Document (ED) contains and addresses the proposed Herring FMP and associated implementing regulations, and reasonable alternatives to the proposed Herring FMP. In so doing, the ED is intended to serve as the functional equivalent of an EIR under CEQA. As noted above, however, preparation of the ED is not a "blanket exemption" from all of CEQA's requirements [*Environmental Protection Information Center v. Johnson* (1985) 170 Cal.App.3d 604, 616-618; see also *Wildlife Alive v. Chickering* (1976) 18 Cal.3d 190]. Instead, the Commission must adhere to and comply with the requirements of its certified program, as well as "those provisions of CEQA from which it has not been specifically exempted by the Legislature" [*Sierra Club v. State Board of Forestry* (1994) 7 Cal.4th 1215, 1228].

1.4.1 Proposed Action

For purposes of CEQA and this ED, the proposed action consists of the adoption of the Herring FMP and its associated implementing regulations that govern Herring fishing activities in California, as outlined in Chapter 7. The various management tools and alternatives available will be described including the stated policies, goals, and objectives of FMPs under the MLMA. The Herring FMP will continue to be managed through ongoing oversight and management of the fishery by the Commission.

1.4.2 Scoping Process

As discussed above, the MLMA calls for meaningful constituent involvement in the development of each FMP. In addition, CEQA requires public consultation during lead agency review of all proposed projects subject to a certified regulatory program [See PRC §21080.5 (d)(2); see also CCR Title 14 §781.5). The adoption of the Herring FMP and its associated implementing regulations is such a project under CEQA. In addition to the requirements of the MLMA, CEQA requires public consultation on all environmental projects. The Department accomplishes this through a public comment period, scoping sessions within the communities involved, or at least two Commission meetings. As outlined above in Section 1.2, the Department went through a multi-phased iterative process with stakeholder groups as well as the SC in development of this FMP.

In August 2018, the Commission, with support from the Department, prepared and filed a Notice of Preparation (NOP) with the State Clearinghouse for distribution to appropriate responsible and trustee agencies for their input and comments. Further, the notice was provided to individuals and organizations that had expressed prior interest in regulatory actions regarding Herring. On behalf of the Commission, the Department held a scoping meeting on August 25, 2018. Appendix Q contains a copy of the notices as well as a summary of all comments received during the scoping period

1.4.3 Tribal Consultation

Pursuant to CEQA §21080.3.1, as well as the Department's Tribal Communication and Consultation Policy, the Department and Commission provided a joint notification to tribes in California. The letters to the individual tribes were mailed on August 1, 2018. The Commission received a response confirming that the proposed project is outside of the Aboriginal Territory Stewarts Point Rancheria Kashia Band of Pomo Indians. The Indian Canyon Band of Costanoan Ohlone People requested a Native American Monitor and an Archaeologist be present on site at all times if there is to be any earth movement within a quarter of a mile of any culturally sensitives sites. The Department confirmed the project does not involve any earth movement within a quarter mile of any culturally sensitive sites.

The Department initially informed tribes that a FMP for Herring was being developed in a letter dated July 5, 2016. As a follow-up to the initial introduction by mail, Department staff met with Graton Rancheria staff per requested on September 20, 2016 to provide additional details on the FMP process and scope. A subsequent letter soliciting tribal input on the management objectives outlined in the FMP was mailed to tribes on March 28, 2018. Appendix Q contains copies of the tribal notification letters.

1.4.4 Public Review and Certification of the Environmental Document

The Commission's certified regulatory program and CEQA itself require that the Draft ED (DED) be made available for public review and comment (CCR Title 14 §781.5(f); PRC §21091). Consistent with these requirements, and upon the filing with the Commission of the draft Herring FMP and implementing regulations proposed by the Department, as well as the filing of the same documents with the State Clearinghouse at the governor's Office of Planning and Research, the DED will be made available for public review and comment for no less than 45 days. During this review period, the public is encouraged to provide written comments regarding the DED to the Commission at the following address:

California Fish and Game Commission
P.O. Box 944209
Sacramento, California 94244-2090

Additionally, oral testimony regarding the proposed Herring FMP and DED will be accepted by the Commission at the public meetings announced under a separate cover. Public notice of the Commission meeting will be provided as required by the FGC.

The Department is required by law to prepare written responses to all comments on the DED and proposed Herring FMP received during the public review period that raise significant environmental issues (CCR Title 14 §781.5(h); see also PRC §21092.5). In some instances, written responses to comments may require or take the form of revisions to the DED or the proposed Herring FMP, or both. Any such revisions, along with the Department's written responses to comments raising significant environmental issues shall constitute the Final ED (FED). The Commission will consider the FED and the proposed Herring FMP at a public hearing scheduled to be held in San Diego on October 9-10, 2019. Public notice of the Commission meeting will be provided as required by CEQA and the FGC. Notice of any final decision by the Commission regarding the FED and Herring FMP will be provided to the extent required by law.

Chapter 2. Biology of the Species

This chapter describes what is known about the natural history and population dynamics of Herring stocks in California. When information is unavailable for California stocks, information from other Herring stocks along the coast of North America is summarized. This chapter is intended to be a resource for understanding the biology of the stock as it pertains to management.

2.1 Natural History of the Species

The Herring is a member of the family Clupeidae, which also includes the Pacific Sardine, *Sardinops sagax caeruleus*, and American Shad, *Alosa sapidissima*. Historically, Herring were thought to be a subspecies of Atlantic Herring (*C. harengus*) (Blaxter, 1985). However, recent taxonomic literature has designated the Herring a separate species (Grant, 1986; Robins and others, 1991). *C. pallasii* is thought to have diverged from Atlantic Herring soon after the opening of the Bering Strait about 3.5 million years ago (Grant, 1986; Liu and others, 2011). Herring have persisted through many climatic fluctuations, such as the glacial-interglacial cycles of the Pleistocene epoch, though their range has shifted over time in response to oceanic cooling and warming cycles (Liu and others, 2011).

Herring are dark blue to olive green on their backs and silver on their sides and belly (Figure 2-1) and this coloration helps reduce predation in a visual environment (National Oceanic and Atmospheric Administration, 2014b; Sigler and Csepp, 2007). Herring can grow up to 46 centimeters (18 inches (in)) in the northern parts of their range (National Oceanic and Atmospheric Administration, 2014b). The body is elongate with a deeply forked caudal fin, and a lateral line on each side of the fish (Hourston and Haegele, 1980; Lassuy and Moran, 1989). The mouth is terminal, moderate in size, without teeth, and directed moderately upward, with a protruding lower jaw (Hourston and Haegele, 1980; Lassuy and Moran, 1989). This allows adult and juvenile Herring to switch between particulate feeding and filter-feeding modes depending on prey size (Blaxter, 1985). Like all clupeids, Herring are physostomous, meaning that the swim bladder is connected to the gut and thus allows the fish to actively control its buoyancy (Blaxter, 1985; Carls and others, 2008b).

Figure 2-1. Herring, with identifying features noted.

2.2 Distribution of Herring

Herring are found throughout the coastal zone from Baja California to Alaska and across the north Pacific to Japan (Figure 2-2) (Spratt, 1981). A deep genetic division occurs between western and eastern Pacific populations (Hay and others, 2008; Liu and others, 2011). In the northeastern Pacific, it is thought that Herring exhibit three different life history forms: 1) a long-lived, migratory ocean form; 2) a coastal form that migrates short distances or not at all; and 3) a resident form that spends its life in low salinity estuarine systems (Beacham and others, 2008; Carls and others, 2008b). Herring distribution is heavily influenced by these differing life history strategies.

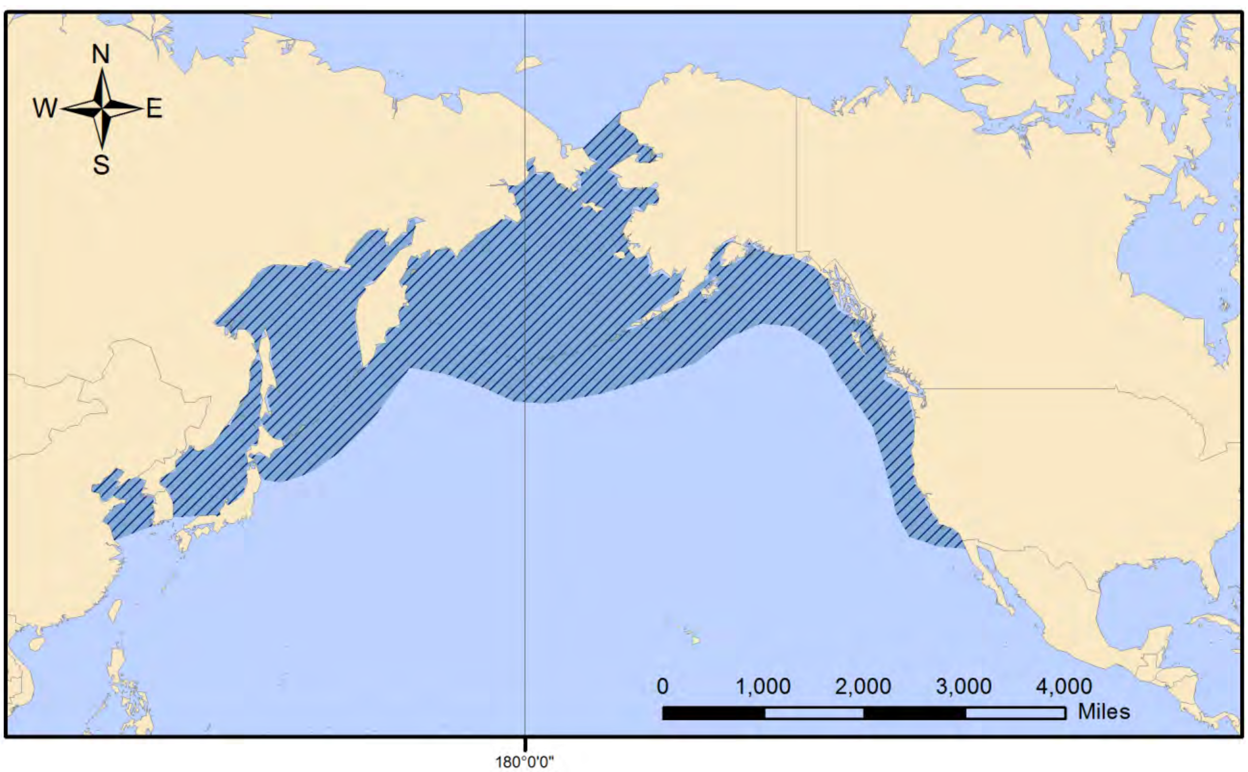

Figure 2-2. Approximate distribution of Herring throughout the northern Pacific.

2.3 Reproduction and Life Cycle

Herring spawn once per year in the winter (Hay and others, 2001; Watters and others, 2004). During the spawning season, Herring congregate in dense schools in the deep-water channels of bays while their gonads mature for up to two weeks, then gradually move inshore to intertidal and shallow subtidal areas of bays and estuaries (California Department of Fish and Game, 2015; Spratt, 1981). Spawning may be triggered by nighttime high tides (Spratt, 1981), neap tides (Hay, 1990), temperature (Hay, 1985), or lowered salinity due to fresh water inputs, though the mechanisms are not well understood. A homing instinct has been demonstrated in Canada (Tester, 1937) and it is possible that each spawning ground supports a stock that is distinct to some degree from adjacent stocks. However, the fluctuations in observed spawning locations in San Francisco Bay (Spratt, 1992; Watters and others, 2004) (Section 3.4, and Appendix D) suggest that other factors may influence choice of spawning location from year to year.

Herring display coordinated sexual behavior, in which a few sperm-releasing males can induce spawning behavior in a large number of fish (Hay, 1985; Rounsefell, 1930; Stacey and Hourston, 1982). During spawning, males release milt into the water column while females extrude adhesive eggs onto available substrate (Figure 2-3). Herring in California have been known to spawn on subtidal vegetation, such as eelgrass, *Zostera marina,* and red algae, *Gracilaria* spp., as well as rocks, shell fragments, and man-made structures, such as pier pilings, riprap, and boat hulls (California Department of Fish and Game, 2015). Sediment on the substrate may inhibit spawning (Stacey and Hourston, 1982). Spawn density varies from an egg or two per square meter of substrate to complete coverage in layers up to eight eggs thick (Spratt, 1981), and up to 16 eggs thick in San Francisco Bay.

Figure 2-3. Herring eggs on eelgrass.

Embryos (fertilized eggs) hatch in 8-14 days, determined mainly by water temperature (California Department of Fish and Game, 2015; Vines and others, 2000), producing slender, transparent larvae about 6-8 millimeter (mm) (0.2-0.3 in) long (Spratt, 1981). Warmer temperatures may lead to smaller egg size and earlier hatches. Incubation time was 6-10 days in water temperatures of 8-10 degrees Celsius (°C) (46-50 degrees Fahrenheit (°F)) in Tomales Bay (Miller and Schmidtke, 1956) and 10.5 days at an average water temperature of 10°C (50°F) in San Francisco Bay (Eldridge and Kaill, 1973). Larvae have a yolksac and limited swimming ability immediately after hatching. Their distribution is clumped, controlled largely by tidal factors (Henri and others, 1985). The duration of the yolksac stage is dependent on the amount of yolk present and temperature (Fossum, 1996).

The spawning season is followed by increasing temperature and productivity in San Francisco Bay, providing food for young Herring (Watters and others, 2004). At about three months of age and 38 mm (1.5 in) in length, Herring metamorphose into their adult form and coloration (Spratt, 1981). In San Francisco Bay, juvenile Herring typically stay in the bay through summer, and then most migrate out to sea (California Department of Fish and Game, 2015). They mature and spawn in their second or third year. Little is known about Herring from the time they leave inshore waters until they are recruited into the adult population at age two or three.

2.4 Spawning Season

In California, schools of adult Herring migrate inshore to bays and estuaries to spawn, beginning as early as October and continuing as late as April (California Department of Fish and Game, 2015). In San Francisco Bay, the spawning period is typically from November to March, with peak levels of spawning occurring most often from December through February (Watters and others, 2004).

Spawning becomes progressively later for stocks further north (Table 2-1). In Humboldt Bay and Crescent City Harbor spawns typically begin later compared to San Francisco Bay. The largest fish typically spawn early in the season and smaller fish spawn in subsequent waves (Reilly and Moore, 1985; Ware and Tanasichuk, 1989).

Table 2-1. Timing of Herring spawning season along the West coast of North America.

Location	Spawning Season
Gulf of Alaska and the southeast Bering Sea	March through May
British Columbia	January through May
Washington	Mid-January through early June
California	November through March

Figure 2-4 shows the magnitude and timing of all spawns observed in San Francisco Bay since 1973. Throughout the history of the fishery, 65% of observed spawns have been in areas around the Marin shoreline (Table 2-2), suggesting that the spawning grounds in and around Richardson Bay provide critical spawning habitat for the San Francisco Bay Herring population. The locations of spawns have changed over time. Some locations are used for several consecutive years and then abandoned. For example, Marin was the primary spawning area in the majority of seasons in the 1970s, but after a large storm in 1982-83 the San Francisco Waterfront became the dominant spawning location until the mid-90s (Spratt, 1992). Since the 2008-09 season, Point Richmond, in the North East Bay, has become an important spawning ground despite not being a historically important spawning ground.

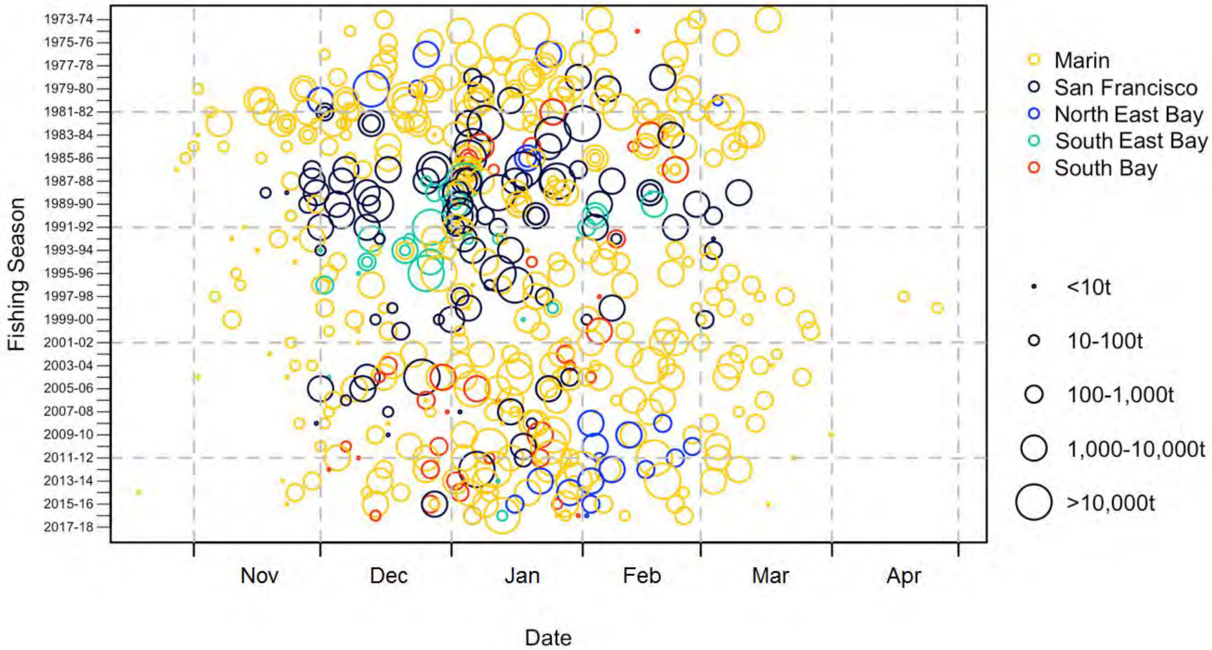

Figure 2-4. Distribution of dates (x-axis), magnitudes, and locations of observed spawns in San Francisco Bay from 1973-17 fishing seasons (y--axis). See Figure 2-12 for a map of these locations.

Table 2-2. Summary of observed spawns in five regions in San Francisco Bay. For a map of these locations see Figure 2-12.

Spawn Area	Percent of Observed Spawns (1973-74 to 2016-17)	Average number of Spawns per year	Earliest date observed	Latest Date observed	Peak Month
Marin	65.3	9	Oct 19 (2014)	Apr 26 (1999)	Jan
San Francisco	18.5	2.5	Nov 18 (1988)	Mar 10 (1989)	Jan
North East Bay	4.3	0.6	Dec 1 (1980)	Mar 5 (1981)	Feb
South East Bay	5.6	0.8	Dec 1 (1993)	Feb 18 (1990)	Dec
South Bay	6.3	0.9	Dec 3 (2015)	Feb 23 (1987)	Jan

2.5 Movement

Adult Herring move between spawning areas in the winter and feeding areas in the summer (Kvamme and others, 2000; Sigler and Csepp, 2007). During the spawning season (i.e., November through March in California), Herring congregate in dense schools and migrate inshore to intertidal and shallow subtidal areas of bays and estuaries (Moser and Hsieh, 1992; Spratt, 1981). During spring and summer months, Herring move offshore to feed, forming dense pelagic schools (California Department of Fish and Game, 2015; Carls and others, 2008b; Sigler and Csepp, 2007). Generally, they school close to the seafloor in continental shelf waters less than 200 meter (m) (656 feet (ft)) deep (Hay and McCarter, 1997) and at dusk they move towards the surface and feeding activity increases (Blaxter, 1985). The specific oceanic distribution of California's Herring stocks is unknown. The availability of suitable prey is likely the determining factor in Herring's migration pattern and behavior in the feeding period (Kvamme and others, 2000).

Most of what we know about Herring movement in California comes from observations of their behavior in bays during the spawning season (Section 2.2.3). Herring typically hold in deep water (>18 m) (>59 ft) for several days as they ripen for spawning (Watters and Oda, 2002), before moving in to intertidal and shallow subtidal areas to spawn (Watters and others, 2004). Spent Herring leave the bay soon after spawning and may travel over 150 kilometers (km)/week (93 miles (mi)/week) (Carls and others, 2008b; Watters and others, 2004). Many Young of the Year (YOY) Herring remain in the bay until summer and emigrate offshore between June and October (Fleming, 1999; Watters and others, 2004).

Little is known about the offshore movement of Herring in California. However, Herring have been collected in trawls in the Gulf of the Farallones (GOF) (Reilly and Moore, 1985) and landed commercially during summer months in Monterey Bay fishing port areas. There is also evidence that the Tomales Bay population moves offshore during the nonbreeding season while the San Francisco population remains onshore, moving down the coast to Monterey Bay (Moser and Hsieh, 1992). This is consistent with the thought that Herring in the northeastern Pacific exhibit a number of different life history strategies. Some Herring populations (i.e., Northern Bristol Bay Herring) are known to migrate as far as 2,100 km (1,304 mi) (Tojo and others, 2007), while others display more resident behavior (Beacham and others, 2008).

2.6 Diet and Feeding Behavior

Diet study data for Herring in California are incomplete, though studies have been conducted for other populations. In San Francisco Bay, a large portion of larval Herring diet is composed of tintinnids, a single-celled microzooplankton (Bollens and Sanders, 2004). Juvenile Herring feed on a variety of micro-plankton (diatoms, protozoans, bivalve veligers, and copepod eggs, nauplii, and copepodites) (Purcell and Grover, 1990). Juvenile Herring in shallow subtidal areas feed primarily on zooplankton (copepods and crab larvae) (Fresh and others, 1981).

Herring continue to feed on plankton throughout their life cycle, relying heavily on visual cues in feeding (Blaxter and Holliday, 1963). During the feeding season Herring also move diurnally to maximize access to prey, conserve energy, and avoid predation (Carls and others, 2008b). Adult Herring schools spend the day near the seafloor and move toward the surface at dusk, where feeding activity increases and fish scatter as light decreases (Blaxter, 1985). Herring may release gas from their swim bladders as they ascend (Thorne and Thomas, 1990). As light increases again at dawn, the school reforms and moves back into deeper water (Blaxter, 1985). This diel vertical migration cycle may be an adaptation for optimal feeding or to reduce predation (Blaxter, 1985).

Herring diet changes as a function of size, time of year, and habitat, and there may be very little direct competition for food between age classes (California Department of Fish and Game, 2015; Hay, 2002). Adult Herring in Alaska are known to feed on a variety of organisms, from euphausiids (krill) and copepods to salmon fry (Stokesbury and others, 1998). Adults will switch feeding forms (filter or particulate feeding) based on food concentration and size to maximize number of prey (Blaxter, 1985; Boehlert and Yoklavich, 1984; Gibson and Ezzi, 1985).

2.7 Natural Mortality

2.7.1 Annual Mortality Rates and Sources

Natural mortality is defined as all the sources of death for a fish population other than fishing (Ricker, 1975). Sources and annual rates of natural mortality for Herring differ at various life stages, with mortality typically being greatest during the first year of life (Table 2-3, Appendix A). Survival of eggs is highly variable, and thus a large number of eggs laid in a given year does not necessarily correlate with a strong year class (Watters and others, 2004). Larval survival is likely the major determinant of year class strength (Carls and others, 2008b), and a study in San Francisco Bay found the Catch Per Unit Effort (CPUE) of juvenile Herring in the bay (~3-8 months old) to be correlated with spawning biomass three years later (Sydeman and others, 2018). Once juveniles leave the bay (August-October) they begin to school to minimize predation risk (Carls and others, 2008b). Mortality rates for adult Herring worldwide are between 30 and 40% (Stick and others, 2014), though higher (and increasing) mortality rates have been documented in some Herring stocks.

Table 2-3. Summary of estimated natural mortality rates and sources for Herring at different life stages.

Life Stage	Mortality Rate	Sources of Mortality	Reference
Egg	66–100%	Wave action, predation, smothering by dense egg deposits, hypoxia, desiccation, temperature, and microorganism invasions	(Rooper and others, 1999)
Larvae - Post Hatch	0–50%	Physiological abnormalities, such as underdeveloped jaws, which leads to starvation	(Norcross and Brown, 2001)
Larvae - Dispersal Period	93–99%	Starvation or predation	(Norcross and Brown, 2001; Purcell and Grover, 1990)
Juveniles	1–98%	Starvation, competition, predation, and disease	(Norcross and Brown, 2001)
Adults	30 and 40% (with some estimates as high as 60%)	Predation, disease, starvation, competition, or senescence, and observed increases in mortality could also be caused by pollution or climatic shifts	(Bargmann, 1998; Gustafson and others, 2006; Stick and others, 2014)

2.7.2 Estimates for Instantaneous Mortality Rates

Mortality for fish is often reported as an instantaneous natural mortality (M) and is one of the most important and uncertain life history parameters in fishery management. In Herring populations estimates of M have varied substantially over time and life history stage (Cleary and others, 2017; Stokesbury and others, 2002). In British Columbia, M was found to increase with age from 0.21 to 0.67 between ages four and eight and was greater than 0.99 for older ages (Tanasichuk, 2000). In addition to varying with age, M has been found to vary over time, suggesting that it likely fluctuates in response to environmental conditions (Fisheries and Oceans Canada, 2016).

An age-structured stock assessment model commissioned for the San Francisco Bay Herring stock by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) had difficulty estimating M for the San Francisco Bay Herring stock (Appendix B). Instead, values ranging from 0.27 to 0.61 (corresponding to annual mortality rates of 23-45%) were explored. In addition, this assessment explored increasing M in older (age six and older) Herring because it improved fits to the available data.

2.8 Maximum Age and Age Structure of the Population

Herring in California are considered a short-lived species and generally, few fish live longer than 9 years (yr), though longevity may exceed 15 yr (Ware, 1985). Maximum age of Herring increases with latitude (Carls and others, 2008b; Hay and others, 2008), with fish in northern populations living up to age 19 and fish in extreme southern populations typically living only 6 or 7 yr (Hay and others, 2008). The San Francisco population is towards the southern end of Herring's range and fish older than 7 yr do not form a large component of this stock.

Herring scales and otoliths can be used to determine the age of individual Herring. The Department has collected otoliths from the Herring research catch during each winter spawning season since 1982-83 to track the stock's age structure in San Francisco Bay (Figure 2-5). The age composition of spawning populations is influenced by dominant year classes and can vary considerably. For example, a strong recruitment event in 2009-10 was observed, but since then the proportion of age two fish observed in the research catch has declined, which may be attributed to unprecedented warm water and drought conditions from 2014-16, driven in part by the North Pacific Marine Heatwave (Section 3.2).

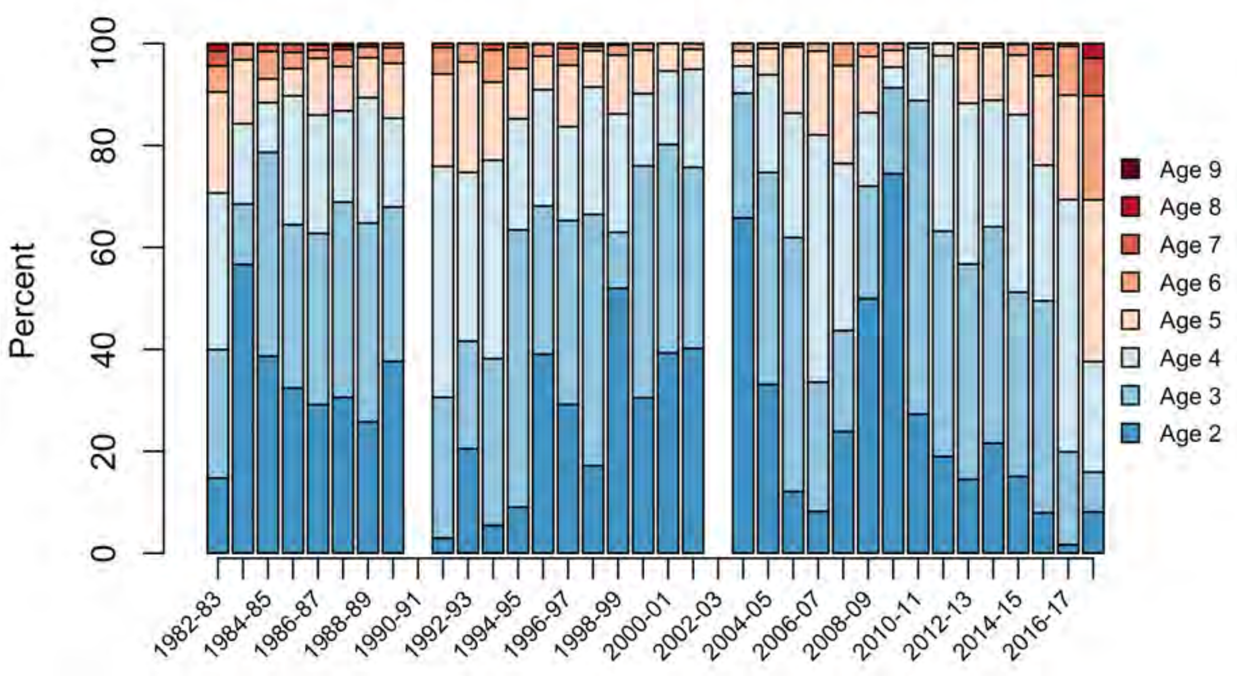

Figure 2-5. Percent at age, by number, of ripe fish for the San Francisco Bay spawning stock biomass. Based on age composition of the research catch (excluding age-1 fish), 1982-83 through 2017-18 seasons. Note that final age composition was not determined for the 1990-91 and 2002-03 seasons.

In the late 1990s and 2000s, a truncation in the age structure was observed, with few fish over age six recorded. This led to concerns that the harvest rate was negatively impacting the age structure of the stock, and fishing pressure was reduced due to lower harvest rates from 2004 onward. In recent years Department staff have observed an increase in older fish (age six and older) in their samples, indicating that 6 and 7 yr old Herring are once again present in the San Francisco stock.

Age structure data for the Humboldt Bay population were collected during the 1974-75 and 1975-76 season and provides information on the age structure of the stock when it was lightly fished (Table 2-4). The maximum age observed was 11, and almost 20% of the stock was over age eight. There are no recent data on the age structure from Humboldt Bay.

Table 2-4. Observed age composition in the Humboldt Bay stock between 1974-76 (Rabin and Barnhart, 1986).

Age	1974-75		1975-76	
	Number Sampled	Percent	Number Sampled	Percent
2	75	29.6	97	33.6
3	42	16.6	68	23.5
4	41	16.2	33	11.4
5	19	7.5	28	9.7
6	11	4.3	14	4.8
7	19	7.5	10	3.5
8	30	11.9	25	8.7
9	11	4.4	10	3.5
10	3	1.2	3	1
11	2	0.8	1	0.3
Total	253	100	289	100

2.9 Growth Information

2.9.1 Larval Growth

At the time of hatching, Herring larvae are approximately 7.5–9.0 mm (0.30-0.35 in) in length (Carls and others, 2008b; Hart, 1973; Hourston and Haegele, 1980). A growth rate of 0.48–0.52 mm/day (0.019-0.020 in/day) was estimated for larvae during the first 15 days of life (Alderdice and Hourston, 1985; Carls and others, 2008b). The body begins to change over the next five weeks as it deepens and forms rudimentary fins, and by week ten, with a length of approximately 25 mm (0.98 in), larvae begin to metamorphose into juveniles, taking on the general appearance of adults and begin developing scales (Carls and others, 2008b; Hourston and Haegele, 1980). After about three more weeks, metamorphosis is complete and juveniles are approximately 35 mm (1.4 in) long (Hourston and Haegele, 1980). Growth over the summer is quick, and juveniles typically reach a length of 100 mm (3.93 in) by fall, whereas little growth occurs during the winter (Hourston and Haegele, 1980). Herring in San Francisco Bay reach approximately 100 mm (3.9 in) in average length by age one.

2.9.2 Length at Age

Adult Herring typically range from 130–260 mm (5-10 in) in total length depending on the region, though larger Herring have been observed in Alaska

(Emmett and others, 1991; Hart, 1973; Miller and Lea, 1972). Herring in the San Francisco Bay spawning population range in size from approximately 100-240 mm (4-9 in) in body length (BL).

A comparison of growth curves from Herring sampling in San Francisco Bay in the 1970s (Spratt, 1981) and more recent years (1998-17) suggests that the length at age has been declining (Figure 2-6). Growth is highly variable from year to year due to variations in parental/adult biomass, initial larval mass, fish abundance, sea temperature, salinity, or other oceanographic factors (Tanasichuk, 1997). The Spratt (1981) growth curve may therefore reflect a time period of better growth conditions, however, the lower length at age in the more recent years may also reflect a long-term change in size at age attributed to either selective fishing pressure or changing climatic conditions, as has been documented in other Herring stocks (Fisheries and Oceans Canada, 2016; Wheeler and others, 2009), and appears to be the case with other size metrics for San Francisco Bay Herring.

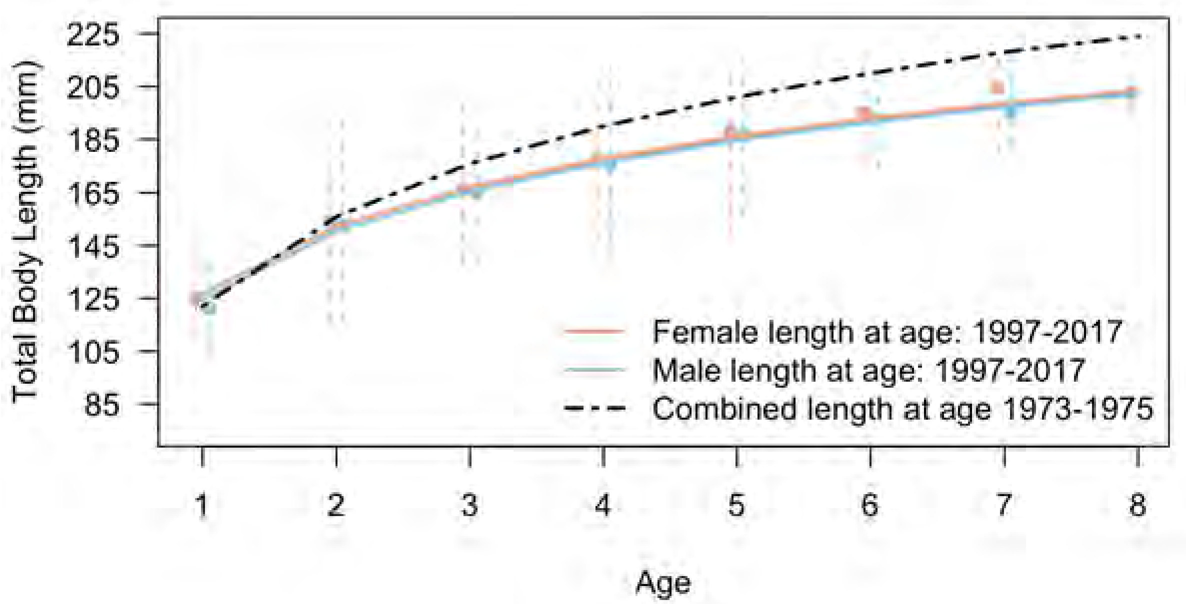

Figure 2-6. Mean length at age (dots), observed length distribution at age (dashed vertical lines), and modeled length at age for male (blue) and female (pink) Herring in San Francisco Bay between 1998-17 is contrasted with the modeled length-at-age for San Francisco Bay Herring from 1973-75 (black dot and dash line, sexes combined) (Spratt, 1981).

In addition to temporal variability, Herring also show a great deal of spatial variability in growth. San Francisco Bay Herring are near the southern end of their range and thus have smaller maximum sizes (Schweigert and others, 2002). Spratt (1987) found that Tomales Bay Herring are 1–10 mm (0.03-0.40 in) larger at each age than San Francisco Bay Herring. This latitudinal cline does not always hold, however, as environmental factors or life history strategies can have stronger effects on growth. Data on growth and size at age are lacking for Humboldt Bay and Crescent City Harbor stocks.

The Department has collected weight and length data as part of its ongoing sampling program since 1973. The data collected between the 1998 and 2017 seasons are summarized in Figure 2-7. Females are slightly heavier at age than males at larger sizes.

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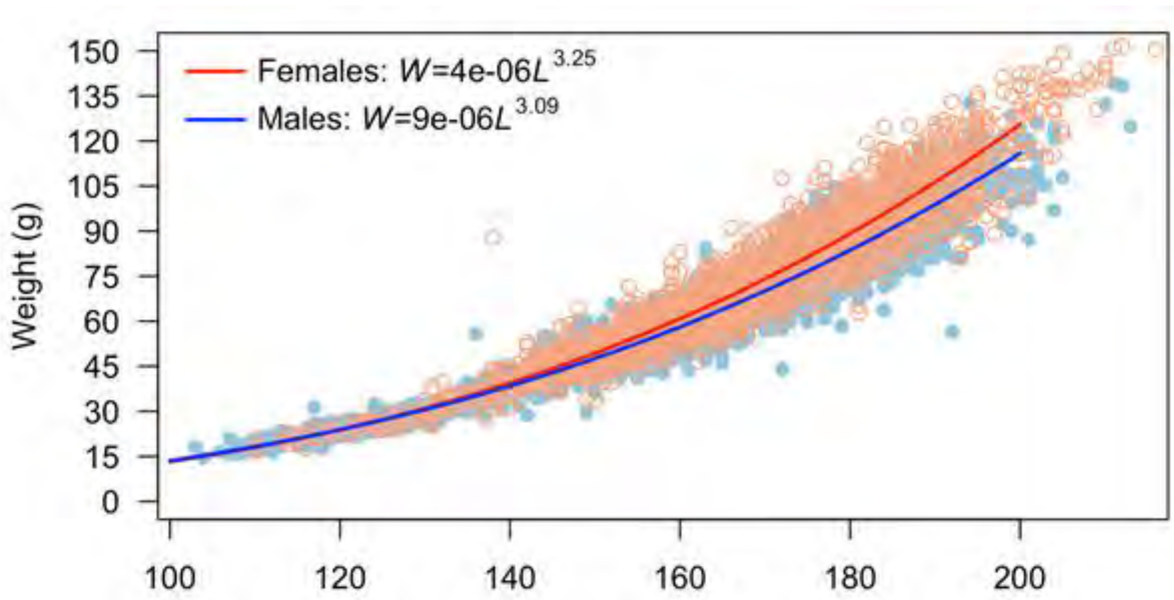

Figure 2-7. Length-weight relationship for mature, unspent San Francisco Bay Herring between 1998 and 2017 (n= 6296, 54% males).

The Department has tracked mean weight at age of San Francisco Bay Herring since 1983 (Figure 2-8). The 1982-83 season corresponded with an El Niño event, and weight at age increased in following years. However, since the mid-1980s there has been a substantial decrease in the weight at age of fish ages five and older. The weight at age of fish ages two to four remain variable but stable through the 1990s but has declined since the early 2000s despite reduced fishing pressure. A similar decline in weight at age has been seen in Herring stocks in British Columbia (Fisheries and Oceans Canada, 2016).

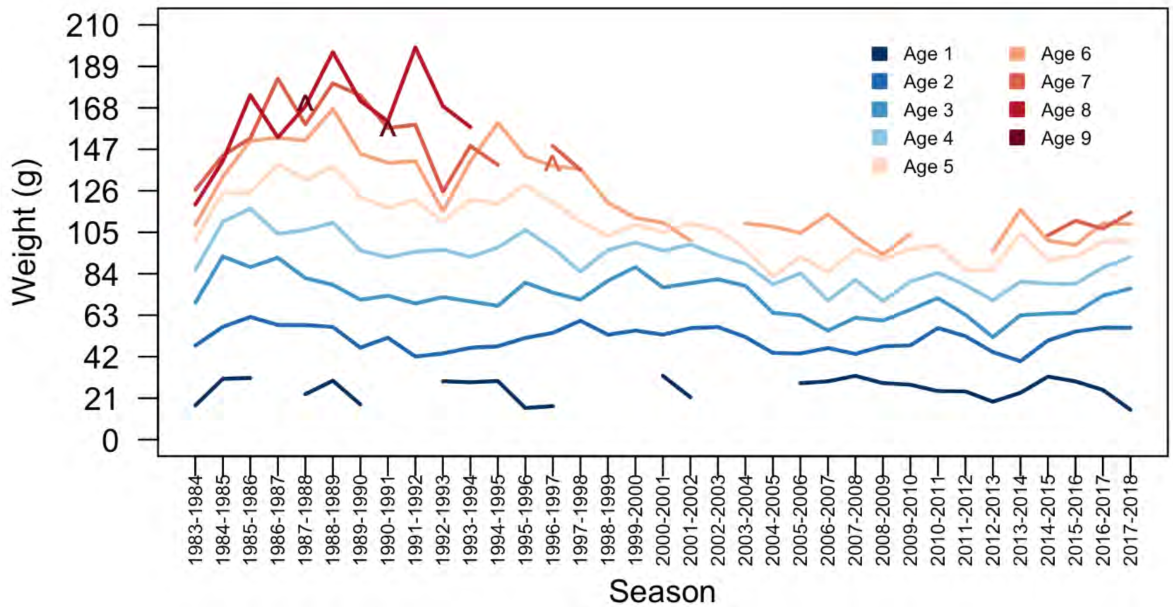

Figure 2-8. Mean weight at age observed in the research catch between the 1982-83 and 2017-18 seasons. Mean weight at age fluctuates from year to year but has declined for age three and older Herring.

2.9.3 Body Condition

Since 1979, each year the observed lengths and weights for mature Herring are used to develop a Condition Index (CI), which is derived from a fish's weight divided by the cube of its length. High condition indices have been associated with increased reproductive capacity and fish survival (Schloesser and Fabrizio, 2017). The average San Francisco Bay Herring CI for mature males and females are shown in Figure 2-9. The CI may be higher in some cool years, and can drop during or shortly after warmer years (Spratt, 1987). Increases may reflect the increased productivity of the CCE during cooler years. The largest reductions in CI were observed during the strong El Niño events in 1982-83 and 1997-98. Despite a recent increase, the long-term CI trend is decreasing, though the underlying cause of that decrease is unknown.

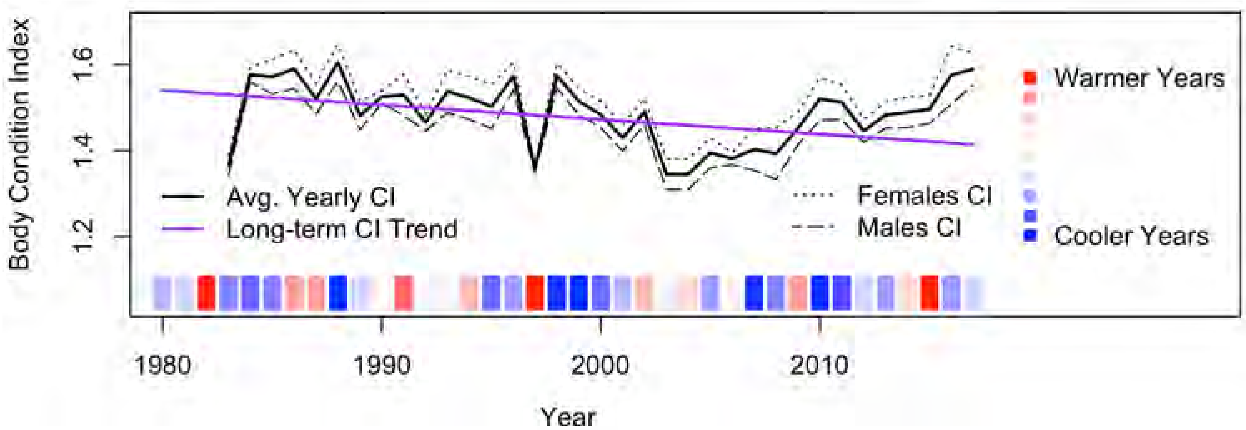

Figure 2-9. Yearly condition index for San Francisco Bay Herring and average SST anomaly[1] in the Eastern Pacific between 1980 and 2018.

2.10 Size and Age at Maturity

Herring are thought to enter the spawning population at age two and by age three all Herring are mature (Spratt, 1981). Some 1 yr old Herring occasionally spawn. In San Francisco Bay, there is a shift in the age and size structure of spawning runs as the season progresses. Early runs tend to be composed of a low percentage of age 2 and 3 yr Herring. These younger Herring mature later in the season and represent a high percentage of late season spawning runs. During years of poor recruitment, when age two and three and older fish appear in low numbers, spawning may cease prior to March. When recruitment of age 2 and 3 yr old fish is high, spawning may continue through March. A broad age structure can enhance the resilience of a stock by averaging out the effects of age on reproduction (Lambert, 1987).

Age at maturity varies spatially and increases with latitude and colder temperatures (Hay, 1985). For instance, Herring mature at 2 to 3 yr in California, 3 to 4 yr in Washington and British Columbia (Outram and Humphreys, 1974), and up to 8 yr in the Bering Sea (Carls and others, 2008b; Emmett and others, 1991; Spratt, 1981). Age at maturity also differs between sexes. Males begin to mature earlier and develop faster than females (Hay and Outram, 1981; Lassuy and Moran, 1989; Ware and Tanasichuk, 1989). Age at maturity is likely related to environmental conditions or cues and fluctuates from year class to year class.

2.11 Fecundity

Various researchers have estimated fecundity of Herring using fish length, weight (e.g., gonadosomatic index), or age (Lassuy and Moran, 1989). Length-specific fecundity has been widely reported to decrease with increasing latitude (Hay, 1985; Lassuy and Moran, 1989; Paulson and Smith, 1977). However, since fecundity increases with body size, mean and maximum fecundities of all

[1] SST Anomaly for the Nino 3.4 Index, averaged for the year. Retrieved on November 12, 2017 from https://www.esrl.noaa.gov/psd/gcos_wgsp/Timeseries/Nino34/

spawners actually increase with latitude as well (Carls and others, 2008b; Hart, 1973; Lassuy and Moran, 1989; Paulson and Smith, 1977). Since 1973, seven fecundity estimates have been generated for California Herring stocks in Humboldt Bay, Tomales Bay, and San Francisco Bay (Table 2-5). The range of average fecundity estimates for female Herring from different California Herring stocks is approximately 210-228 eggs per gram (g) of body weight. For females in San Francisco Bay, the most recent estimate of average fecundity is 210 eggs/g (Table 2-5).

Estimated fecundity is used to calculate annual Spawning Stock Biomass (SSB) from the number of eggs observed in spawn surveys. Because the fecundity of the stock can vary with environmental conditions, as well as among fish of different size class, and because using outdated or poor estimates of fecundity can bias the SSB estimate (Appendix O), fecundity should be estimated frequently, ideally by size class within a stock. However, fecundity measurements are resource intensive, therefore the Department only measures fecundity periodically (approximately once a decade). The Department will continue to estimate fecundity as necessary to determine SSB accurately as staff time allows.

Table 2-5. Summary of fecundity estimates for California Herring stocks.

Reference	Eggs/g Female Body Weight (Average)	Range	Sample Size
Tomales Bay - Hardwick (1973)	228	--	--
Tomales Bay - Kaill (unpublished data) in Spratt (1981)	216	--	--
Tomales Bay – Reilly and Moore (1984)	220	--	--
San Francisco Bay – Reilly and Moore (1986)	226.4		n=96
San Francisco Bay - Ray unpublished data (2014-15)	210	201 - 219	n=30
Humboldt Bay - Rabin and Barnhardt (1977)	220	185 - 255	n=37
Humboldt Bay - Ray unpublished data (2014-15)	228	218 - 238	n=20

2.12 Abundance Estimates

Herring abundance generally increases with latitude. Population size likely depends on the amount of summer feeding habitat (i.e., coastal shelf waters) as well as the presence of suitable spawning habitat, with the largest populations occurring off British Columbia and Alaska (Hay and McCarter, 1997).

Short-lived pelagic fish, such as Herring, can exhibit wide fluctuations in abundance. Herring are highly sensitive to environmental conditions that affect oceanic productivity and can experience large dips in population size even in the absence of fishing. The San Francisco Bay Herring population has shown an increased level of variation in population sizes since 1992, likely driven by increased variation in oceanographic conditions over that time period (Sydeman and others, 2018). However, Herring are highly fecund, and populations in California have increased rapidly following periods of decline.

Because of these dynamics, frequent short-term assessments are valuable for tracking the population status.

Yearly surveys have been the primary assessment method used to manage the Herring stock in San Francisco Bay (Chapter 4). Biomass estimates for the San Francisco stock increased as survey methodologies were refined during the 1970s (Section 6.1.2). Abundance surveys were also conducted yearly in Tomales Bay until the 2005-06 season and have been conducted intermittently in Humboldt Bay (Figure 2-10). Department biomass estimates are derived from egg deposition surveys and total commercial catch data, and may underestimate the true size of the mature stock (also known as the Spawning Stock Biomass, or SSB).

While management has primarily relied on survey-based estimates of abundance, two stock assessments have been conducted to provide modeled estimates of Herring abundance in San Francisco Bay, as well as to estimate other important life history parameters. In 2003 an age structured stock assessment model (Appendix C) was applied to a time series of catch-at-age, SSB estimates from Department surveys, and biological parameters. That study concluded that the while the stock abundance had remained high through the 1970s and 80s, a combination of lower recruitment (likely due to poor environmental conditions) and high exploitation rates in the late 1980s and 90s had lowered stock sizes to 20-25% of those from the early years of the fishery. The Coleraine model suggested that the most significant period of decline was after the strong El Niño in 1997-98 (Appendix C). More recently, in 2011, a second stock assessment model was commissioned for the San Francisco Bay Herring stock by the San Francisco Bay Herring Research Association (SFBHRA), and completed by Cefas in 2017. An age-structured population model was developed, and reference points were estimated using the model (Appendix B). However, due to an inability to fit a stock recruitment relationship and other uncertainties in the model, an independent peer review panel recommended that the stock assessment not be used to estimate SSB or make management decisions until additional analysis was completed (Appendix B).

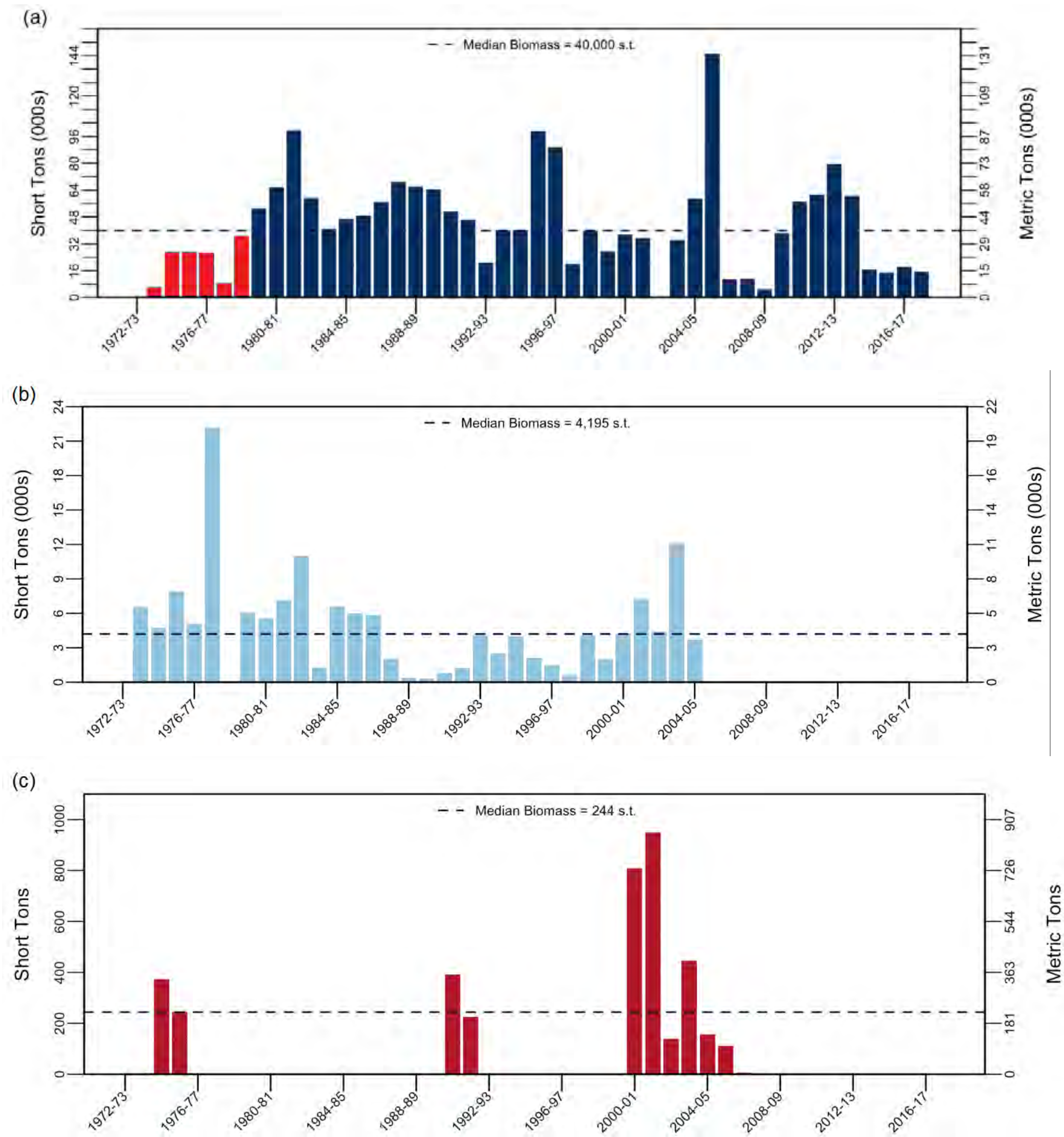

Figure 2-10. Reported estimates of SSB (including catch) for San Francisco Bay (a), Tomales Bay (b), and Humboldt Bay (c) for all seasons in which surveys were conducted. In San Francisco Bay, biomass estimates for seasons prior to 1979-80 represent intertidal spawns only. Note the y-axes scale differs among (a) – (c).

2.13 Habitat

2.13.1 Habitat Needs for Each Life Stage

2.13.1.1 Spawning Habitat

Herring in California spawn primarily in areas that are sheltered from the ocean surf, such as in bays, estuaries, and harbors. Herring have also been reported to spawn in unprotected near-shore coastal waters, though this has not been well studied in California. Spawning may take place in the intertidal zone, defined as the regions that lie between low and high tides, or in subtidal areas, which are always submerged. Herring eggs become sticky after fertilization and adhere to a variety of substrates, rather than float in the water column.

The predominant spawning habitat for Herring in California are beds of submerged aquatic vegetation, both in rocky intertidal areas, and in shallow subtidal areas with substrates composed of combinations of mud, silt, clay, sand, and pebbles/cobbles. Eelgrass is a native marine vascular plant that often forms dense beds that serve as one of the primary subtidal vegetation habitats on which Herring spawn. Eelgrass beds are structurally complex and highly productive habitats which provide refuge, foraging, breeding, or nursery functions for a variety of fishes, including Herring, invertebrates, and birds (Phillips, 1984). Eelgrass beds also enhance stability and prevent shore erosion through wave attenuation, provide nutrient transport, sequester carbon, and improve water quality by filtering organic matter and sediment.

Gracilaria spp. co-occurs with eelgrass in many shallow subtidal areas with soft sediment substrate, and over time vegetation beds in an area can fluctuate between being dominated by one species versus the other (California Department of Fish and Game, 1998; Spratt, 1981). Herring have also been observed to spawn on various other genera of subtidal and intertidal algae, including *Fucus*, *Ulva*, *Macrocystis*, *Laminaria* and *Sargassum*. Bed locations and sizes of submerged vegetation areas are determined by water depth and turbidity, which control light availability, as well as temperature, salinity and storm action. Eelgrass abundance and density is dynamic and beds expand and contract in response to changes in their environment (Section 2.13.3). It is not known how these fluctuations may impact the reproductive success of Herring.

Herring also spawn on natural hard substrates such as boulders, rock face outcrops, and low relief rock, as well as man-made hard substrate including submerged concrete breakwaters, bulkheads, vessel structures, pilings, riprap, and pipelines. These substrates are often covered with multiple species of animals including barnacles, chitons, limpets, anemones, bryozoans, tunicates, oysters, and mussels, as well as green, red, and brown algae. The San Francisco Bay Waterfront has been used consistently as spawning habitat, and in Crescent City Harbor Herring spawns occur on various man-made structures. However, the antifouling agents used in these areas may reduce the survival of Herring embryos and larvae (Vines and others, 2000).

2.13.1.2 Nursery Areas

After hatching, Herring spend 5-9 months in nursery habitats within estuarine ecosystems and utilize a variety of behaviors to adjust their position in the water column. During the summer and fall juveniles begin to leave these protected waters to school in the open ocean. There is limited information on how habitat factors affect the distribution or survival of Herring during these stages, and estuarine ecosystems are highly dynamic, unique, and variable, driven largely by oceanographic, watershed, and geomorphological conditions (i.e. salinity, degree of freshwater input, physical characteristics) (Griffin and others, 2004; Griffin and others, 1998; Haegele and Schweigert, 1985; Hay, 1985; Kimmerer, 2002a; Kimmerer, 2002b; Vines and others, 2000). Mortality at the larval and juvenile larval stages can be high (Hardwick, 1973; Outram, 1958), and may be a primary determinant of Herring year class strength.

Data on the distribution of larval and juvenile Herring within San Francisco Bay is provided by the Department's Bay Study Program (Baxter and others, 1999) using trawl, egg and larval net, and beach seine gear (Section 6.1.2.5). This survey began in 1980 and provides information on the distribution of YOY Herring within San Francisco Bay. Analysis of this dataset indicates that, in years when Delta outflow is lower than normal (as in dry years), more YOY Herring are found at upstream survey stations, with YOY observed in Suisun Bay and the West Delta. In years characterized by high Delta outflow, Herring YOY are found to the west, with YOY observed primarily in Central and South San Francisco Bay. This suggests that fluctuations in outflow and salinity in the Delta each year may determine where viable nursery habitat for Herring YOY occurs.

2.13.1.3 Pelagic Feeding and Schooling Grounds

After Herring move out of their nursery ground and into the open ocean, they inhabit coastal pelagic zones. Adult Herring spend most of their adult life in the open ocean but return to bays and estuaries each winter to spawn. The exact distribution of these schools in terms of their range, depth, and migratory patterns has not been well studied. However, Monterey Bay has been identified as a summer feeding ground for Herring, and based on similarities in parasitic infections, this is likely the same stock that spawns in San Francisco Bay (Moser and Hsieh, 1992). The same study indicated that the Tomales Bay stock had a different suite of parasites, which are more likely to be found offshore, suggesting that the Tomales stock may feed each summer in deeper waters.

2.13.2 Identified Herring Spawning Habitat in California

Herring roe fisheries, which target Herring in harbors and bays during the spawning season, occur in four separate management areas within California (Figure 2-11). The available Herring spawning habitat in these areas has been fairly well studied, and is described below and depicted in Appendix D. Only San Francisco Bay and Tomales Bay have Herring populations large enough to support major fisheries, though small fisheries have occurred historically in Humboldt Bay and Crescent City Harbor. The populations in each of these bays are managed as separate stocks because Herring are thought to return to areas that they were born when they reach spawning maturity.

Herring also spawn in other locations outside the four management areas. For example, Herring have been observed to spawn in San Diego Bay, San Luis River, Morro Bay, Elkhorn Slough, Bodega Bay, Russian River, Noyo River, and Shelter Cove (Figure 2-11) (Spratt, 1981). In 2016-17 a spawning event was documented for the first time in Trinidad Bay, located about 32 km (20 mi) north of Humboldt Bay. Spawning in these areas are thought to be minor and may not occur every year.

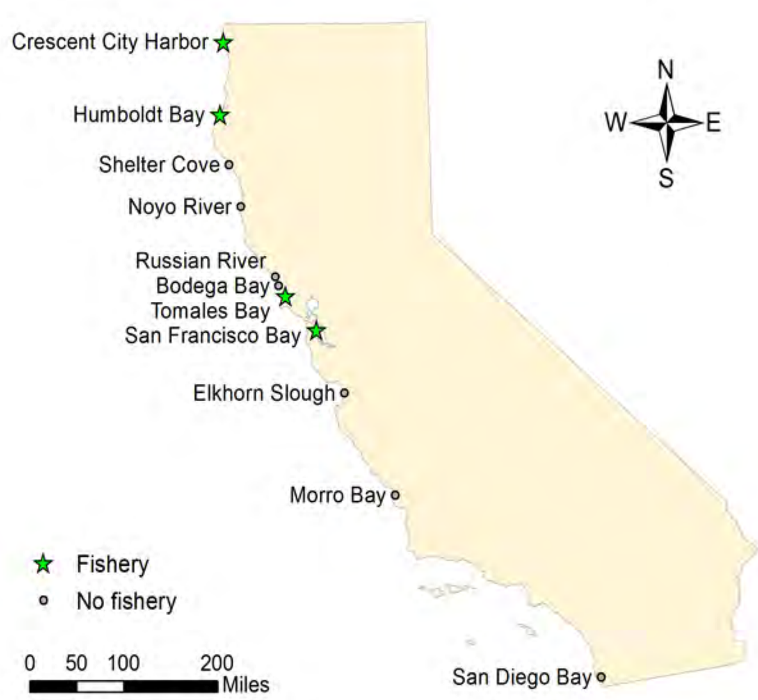

Figure 2-11. Map of observed Herring spawning locations and fisheries in California.

2.13.2.1 San Francisco Bay

The San Francisco Bay estuary, with a surface area of 1,240 km (478 mi), is the largest coastal embayment on the Pacific coast of the United States. San Francisco Bay is a broad, shallow, turbid estuary, with an average depth of 6 m (20 ft) at Mean Lower Low Water (MLLW). The bay is characterized by broad shallows that are incised by narrow channels that are typically 10 m (33 ft) deep, though some are much deeper. Ocean water enters the bay on the tidal cycle and flows up to 60 km (37 mi) from the bay's entrance at the Golden Gate, while fresh water flows into the bay from the Sacramento-San Joaquin drainage basin as well as local streams. Inflow is highly seasonal, and is composed of rainfall runoff during winter and snowmelt runoff during spring and early summer.

In San Francisco Bay, Herring spawn in both the intertidal zone and immediately adjacent subtidal areas as well as in submerged vegetation beds (primarily eelgrass and *Gracilaria* spp.). Habitat types used for spawning include the rocky intertidal and subtidal shoreline of the Golden Gate, rocky intertidal and subtidal shoreline inside the bay, and protected bays and coves with subtidal vegetation, and man-made substrates such as the riprap, pilings, and boat hulls found in marinas or along piers and jetties. The only areas not utilized are mud flats with no vegetation. Figure 2-12 shows the areas where spawning has been observed since spawn surveys began in 1973.

Since the Department began monitoring Herring in San Francisco Bay, the majority of spawns have occurred in Richardson Bay (Section 2.4), where there is a large eelgrass bed of approximately 675 acres (273 hectares) (Merkel and Associates, 2014). This area is closed to gill net fishing for Herring (Section 5.5). Herring also frequently utilize the eelgrass beds along the southern shoreline of the Tiburon Peninsula, including Belvedere and Kiel Coves, as well as those along the East Bay shoreline, from Point San Pablo to Bay Farm Island (Appendix D). The largest eelgrass bed in the estuary is located between Point Pinole and Point San Pablo in San Pablo Bay. This bed was approximately 1,530 acres (619 hectares) during 2014 and composed almost 55% of the total eelgrass coverage in San Francisco Bay at that time (Merkel and Associates, 2014). However, despite its size, there is no Department record of Herring ever utilizing this bed as spawning substrate. In recent years, the waterfront area of Point Richmond, near the Richmond San Rafael Bridge, has become an important spawning habitat for the San Francisco Bay stock.

The vegetation bed areas in San Francisco Bay tend to expand and contract in response to conditions in the bay. Recent mapping efforts showed an increase in eelgrass coverage from 2,700 acres (1,092 hectares) in 2003 to 3,700 acres (1,497 hectares) in 2009, and then a contraction back down to 2,700 acres (1,092 hectares) in 2014 (Merkel and Associates, 2014). These changes in coverage are primarily attributed to changes in temperature and light availability due to turbidity in the water column, which increases during years with high runoff or increased storm action (Sections 2.13.1.1 and 2.13.1.2). In favorable conditions, eelgrass is able to recolonize areas that have lost coverage. Figures 2-13 and 2-14 show the persistence of these beds in the northern and southern portions of San Francisco Bay, respectively. Frequency is defined as the number of survey years (2003, 2009, and 2014) in which eelgrass was observed in each location.

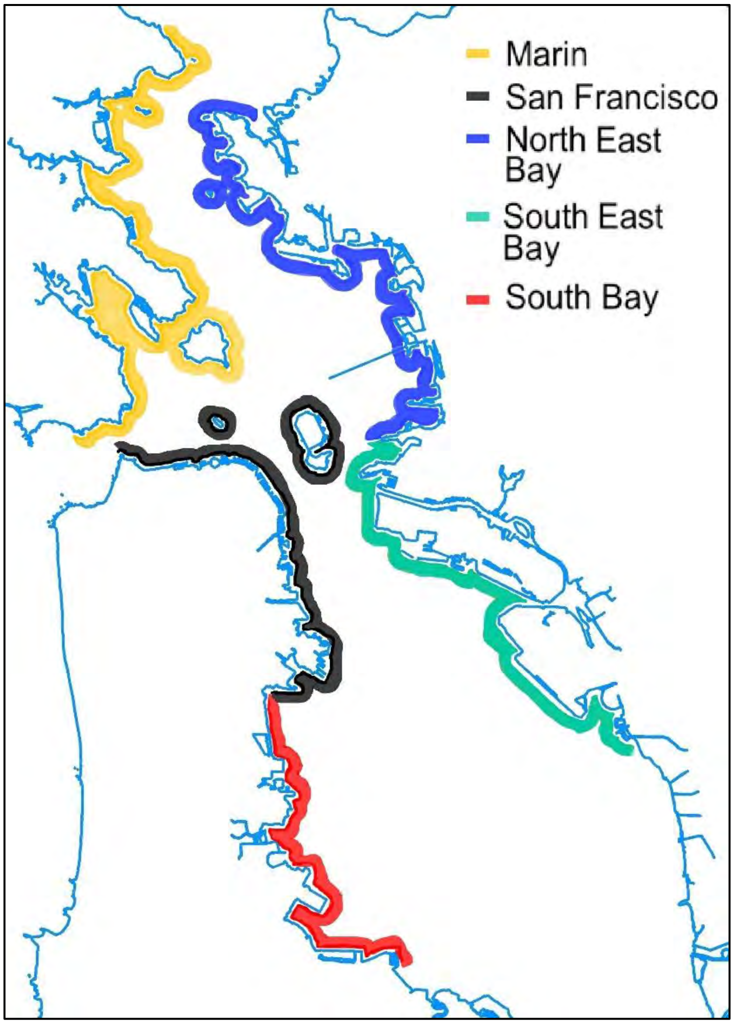

Figure 2-12. Observed spawning locations in San Francisco Bay from 1973 to 2019.

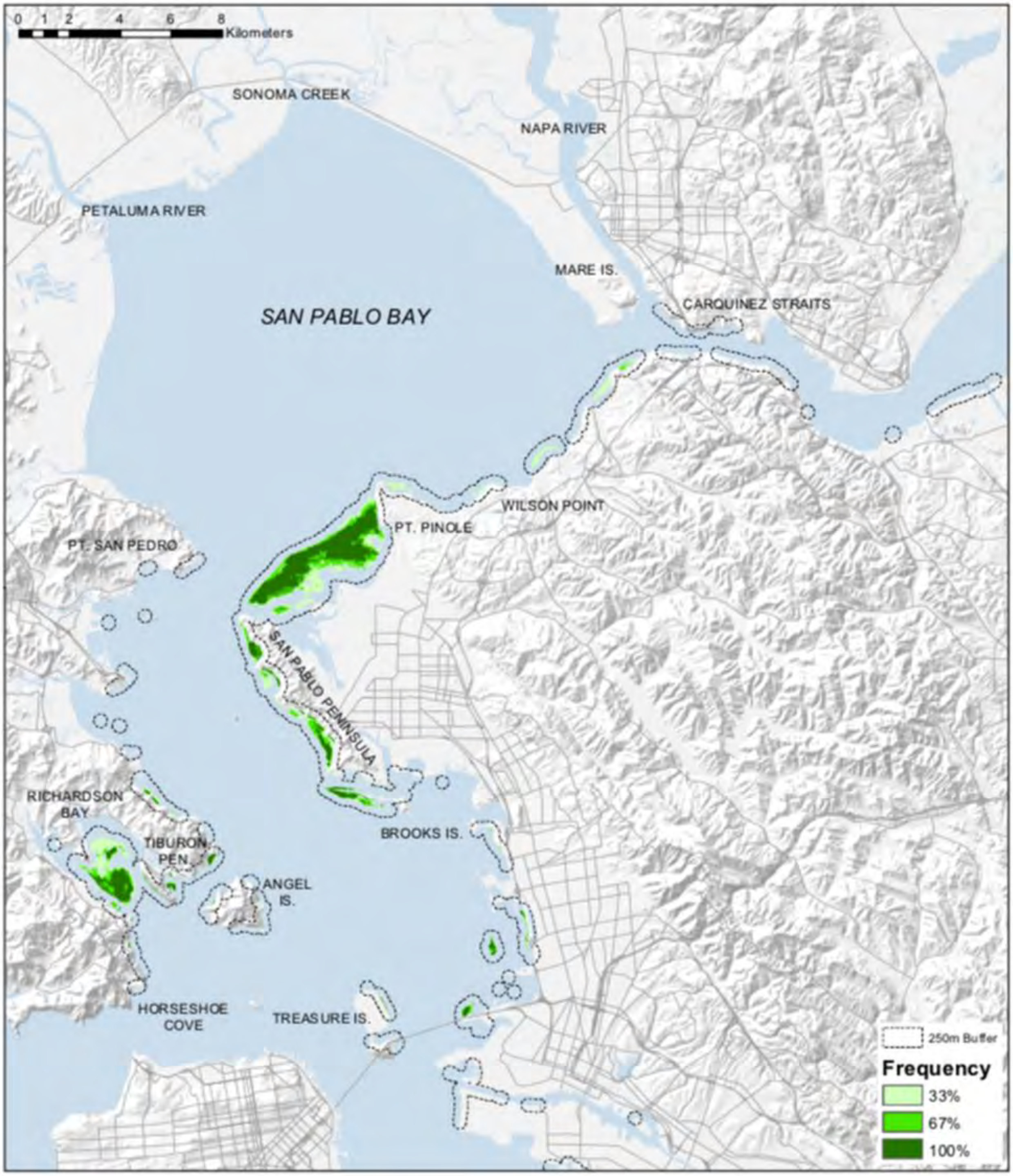

Figure 2-13. Eelgrass distribution and persistence in the northern portion of San Francisco Bay (Reproduced from Merkel and Associates (2014)).

Figure 2-14. Eelgrass distribution and persistence in the southern portion of San Francisco Bay (Reproduced from Merkel and Associates (2014)).

2.13.2.2 Tomales Bay

Tomales Bay lies in Marin County, approximately 48 km (30 mi) north of San Francisco Bay. It is 20 km (12.5 mi) long and averages nearly 1.6 km (1 mi) wide. The bay is completely sheltered from the open ocean, and considerable freshwater runoff enters the bay from numerous streams in the area. Submerged aquatic vegetation beds in Tomales Bay include eelgrass and various species of benthic macroalgae, as well as widgeongrass, *Ruppia maritima,* in the southern-most extent of the bay. Eelgrass is the dominant marine flora in Tomales Bay (Hardwick, 1973; Merkel and Associates, 2017) and the primary spawning habitat for Herring there. In the northern half of Tomales Bay, eelgrass beds are present on shallow, subtidal sand bars, while in the southern half of the bay, they are mostly restricted to narrow bands along the shore at depths no greater than 3.6 m (12 ft) below the MLLW line (Spratt, 1986). Portions of the eelgrass beds are intertidal, becoming completely exposed during lower-low tides. Eelgrass distribution in Tomales Bay is relatively stable from year to year. A 2013 Department mapping effort identified 1,288 acres (521 hectares) of eelgrass habitat in Tomales Bay, while 2017 effort identified 1,527 acres (618 hectares) (Merkel and Associates, 2017). While the overall distribution of eelgrass habitat is relatively stable in Tomales Bay, bed densities are variable and can fluctuate seasonally, as is typical for the species.

2.13.2.3 Humboldt Bay

Humboldt Bay is located approximately 488 km (260 mi) north of San Francisco and is California's second largest estuary. The bay is 23 km (14 mi) long, 7 km (4.5 mi) wide at its widest point, and approximately 65 km^2 (25 mi^2) in size excluding its tributaries and sloughs. Humboldt Bay consists of three main areas, known as North Bay (or Arcata Bay), South Bay, and Entrance Bay. North Bay and South Bay are large shallow basins with extensive intertidal flats that are fully exposed during minus tides. Entrance Bay is composed of a large deep-water channel that connects North and South Bays to the Pacific Ocean. Entrance Bay is periodically dredged to allow for large vessel traffic and has a highly developed shoreline that supports commercial activities.

Eelgrass is the dominant vegetation type in Humboldt Bay, and is the primary spawning habitat for Herring. Eelgrass distribution has been mapped several times in Humboldt Bay between 1959 (Keller, 1963) and 2009 (Schlosser and Eicher, 2012), with estimates of total eelgrass acreage ranging widely during this time. While some of this variation likely reflects actual changes in eelgrass area, primarily in North Bay, due to freshwater inflows, thermal stress, and changes in the intensity of historic shellfish bottom culture practices, some of the variation may also be a function of different survey methods (Merkel and Associates, 2017; Schlosser and Eicher, 2012). At the bay-wide scale, eelgrass extent is generally considered relatively stable through recent time; however, at finer scales, eelgrass in Humboldt Bay is recognized as being fairly dynamic (Merkel and Associates, 2017). Based on data in Schlosser and Eicher (2012), Merkel and Associates (2017) estimate approximately 4,700 acres (1,902 hectares) of continuous eelgrass habitat in Humboldt Bay.

Herring spawning occurs in both North and South Bays, although North Bay typically receives the majority of spawning activity. Spawning has occurred every year in North Bay since the fishery began during the 1973-74 season. Maximum spawning extents observed during the 2014-15 through 2017-18 seasons are presented in Appendix D.

2.13.2.4 Crescent City Harbor

Crescent City is located approximately 560 km (350 mi) north of San Francisco and approximately 24 km (15 mi) south of the Oregon-California border. The majority of Herring spawning events take place in Crescent City Harbor. This makes Crescent City somewhat unique, because the primary spawning habitat is the harbor breakwater and all rocky areas and kelp beds near the harbor, rather than shallow mudflats. It is possible that Herring spawn in areas outside of the harbor, but these areas have not been surveyed by Department staff.

2.13.3 Threats to Herring Habitat

There are a number of threats to Herring habitat from both fishing and non-fishing sources. The Department has direct jurisdiction over and ability to mitigate threats stemming from fishing activities, and does this by restricting the types of fishing gears allowed, requiring gear modifications, or restricting the locations or times of year when fishing activities can occur. The Department considers the threats from fishing activity to Herring spawning habitat in San Francisco Bay to be low. Richardson Bay is closed to Herring gill net fishing, and this provides protection to the eelgrass habitat in this area. However, portions of vegetation beds in areas open to gill netting may be disturbed by gill nets and Herring boat anchors during fishing activities. The habitat impacts from the fishery are short in duration and primarily over muddy habitat in areas that are routinely subjected to disturbance from tides and currents that suspend and deposit material. Potential adverse impacts include scouring of soft-bottom sediments by propeller wash in shallow water areas and disruption of sediments while setting and pulling fishing gear (nets or anchors dragging along the bottom). However, the fine-grained muds found in most fishing areas within the bay are constantly being re-suspended, transported and re-deposited by water movement. The dynamic nature of fine-grained sediment deposition suggests that no significant short-term or long-term impacts to the San Francisco Bay bottom are likely (California Department of Fish and Game, 1998).

Given the unique life history of Herring, the majority of habitat threats in shallow, coastal spawning/nursery ground habitat are from non-fishery sources, such as construction, shoreline development, pile driving, dredging, urban runoff, invasive species, freshwater diversion, vessel traffic, and pollutants. The impacts of each of these threats are described in detail in Table 2-6.

In San Francisco Bay, many of these activities are particularly intense along the San Francisco Waterfront, Port of Oakland, San Francisco–Oakland Bay Bridge, and the Richmond–San Rafael Bridge. In addition, these threats tend to be cumulative, with both direct and secondary impacts on Herring stocks and their habitat. The primary threats to eelgrass and spawning habitats in Tomales and Humboldt Bays include aquaculture practices and damage from vessel mooring. In Tomales Bay, the threat associated with moorings has been mitigated via the adoption of the Tomales Bay Mooring Program in 2017, which prohibits vessels from mooring in seagrass beds. In harbors and marinas such as in Crescent City and along working waterfront areas in San Francisco Bay, the use of antifouling agents also presents a threat to the development of Herring larvae. Crescent City Harbor has also undergone a large amount of construction to repair the harbor after the 2011 tsunami.

Herring spawning habitats in California, particularly eelgrass beds, also face threats from climate change. The distribution of California's eelgrass beds are a function of water temperatures, light availability, and salinity, all of which are variable (Sections 2.13.1.1 and 2.13.1.2). For example, the depth to which eelgrass beds can grow is a function of light penetration, which may be impacted by sea level rise or increased turbidity from storms (Short and Neckles 1999). The intrusion of ocean water into formerly fresh or brackish water areas may cause eelgrass beds to move farther inland (Short and Neckles, 1999). Warmer Sea Surface Temperatures (SST) or greater fluctuations in temperature may also increase the frequency and extent of seasonal die offs (Carr and others, 2012). Warmer temperatures can also increase the incidence of eelgrass wasting disease, which is caused by infection from the opportunist pathogen *Labyrinthula zosterae* and can cause rapid population declines of eelgrass beds (Short and others, 1987). Disease occurred more rapidly and with higher severity in seedlings and at high and fluctuating temperatures (Groner and others, 2016). Changes in the pH of sea water associated with ocean acidification may also impact eelgrass distribution. Increases in the dissolved carbon dioxide content may result in increased productivity in eelgrass beds due to greater carbon availability (Palacios and Zimmerman, 2007), but may also increase rates of grazing on these marine plants due to reduced production of the chemicals that deter predators (Arnold and others, 2012). The cumulative and dynamic nature of these various factors make it difficult to predict how eelgrass beds will be affected by climate change.

Table 2-6. Summary of some threats to Herring habitat and the effects of those impacts on Herring at various life stages.			
Threat	Physical Impacts on Habitat	Effects on Herring	References
Dredging	Dredging can increase suspended sediment concentrations, release sediment-bound contaminants such as chemicals or heavy metals into the water column, reduce dissolved oxygen levels, bury submerged vegetation, increase turbidity, and increase noise in localized areas.	Adult Herring may exhibit an avoidance response in the presence of suspended sediments in the vicinity of their intended spawning site. Sediment on vegetation beds may interfere with the ability of Herring eggs to adhere to the substrate. Suspended sediments can settle onto the eggs interfering with fertilization or by preventing oxygen exchange, and smothering the embryos. The larval fish life stage may be the most sensitive to suspended sediments, and effects include increased precocious larval hatch, higher percentages of abnormal larvae, and increased larval mortality.	(Alderdice and Hourston, 1985; Boehlert and others, 1983; Messieh and others, 1981; Ogle, 2005; Phillips, 1978; Thayer and others, 1975)
Noise	Construction, dredging, and pile driving can produce underwater noise. High intensity noise can be generated by pile driving activities, especially of steel piles. Dredging operations produce lower intensity but continuous noise. Noise in busy coastal harbors generally reaches about 100 dB, peaking at 150 dB in major ports; marine engine noise is in a frequency band of 10-00 Hz.	High intensity noises (> 187 dB) can damage the soft tissues of fish such as gas bladders or eyes, and have been shown to result in mortality of YOY Herring. Lower intensity but continuous noise may cause an avoidance response in adult Herring. Herring have been observed to avoid sounds ranging from 1600-3000 Hz, corresponding to the presence of large vessels.	(Blaxter and Hoss, 1981; Connor and others, 2005; Schwarz and Greer, 1984)

Storms	Large storms may cause increased runoff, which can reduce the salinity in estuarine systems during crucial life history periods. Storms can also increase turbidity and wave action, which can negatively affect both intertidal and subtidal vegetation beds. Storm water runoff or storm surge introduce or re-suspend chemicals and heavy metals.	Large winter storms, such as those that occur during El Niño years, have been observed to remove vegetation beds used for spawning. *Gracilaria* spp. are especially vulnerable to storms, and storms were hypothesized to have altered vegetation beds in Richardson Bay in the early 1980s.	(Alderdice and Velsen, 1971; Bird and McLlachlan, 1992; Costello and C. Gamble, 1992; Griffin and others, 1998; Spratt, 1992)
Changes in Water Outflow	Changes in water flow into the estuaries where Herring spawn, including either very high flows or very low flows, as may occur in drought years or when water is diverted, can impact salinity or water turbidity. These can impact the survival of eelgrass beds, which has an optimal salinity of 10-30 parts per thousand (ppt).	Adult Herring have a wide range of salinity tolerance (4-45 ppt), and can move to achieve their preferred salinity range. However, sudden changes in salinity may cause changes in Herring spawning behavior. The optimal range for fertilization is 12-24 ppt, and embryos and larvae can tolerate a narrower salinity range (8-28 ppt).	(Alderdice and Velsen, 1971; Kikuchi and Peres, 1977; Nejrup and Pedersen, 2008; Phillips, 1984)

Pollutants and Contaminants	Contamination of Herring spawning substrates from antifouling agents or oil spills can reduce survival. Oil contamination can also occur through seawater when no visible oil is present. Substrates can also be contaminated by water-born chemicals, pesticides, and heavy metals.	Exposure to oil can result in decreased survival and hatching success in late stage embryos as well as lower growth rates and increase the probability of deformities in larvae. Embryos that adhere to surfaces with antifouling agents, such as creosote-treated pilings, exhibit morphological deformities, reduced heart rates and reduced hatching rates. Exposure to heavy metals, pesticides, and other pollutants have been shown to reduce egg fertilization and embryo survival by up to 80%.	(Carls and others, 2008a; Carls and others, 2002; Hose and others, 1996; Incardona and others, 2004; Incardona and others, 2012; McGurk and Brown, 1996; Norcross and others, 1996; Vines and others, 2000; Von Westernhagen, 1988)
Boating Activities	Docks and piers can shade submerged areas and cause light-limiting conditions for marine plants or other species. Improper moorings can disturb eelgrass beds, creating barren patches ranging from 3-300 m^2 in eelgrass beds. Boat propellers, anchors and anchor chains can damage vegetation beds.	Boating activities may directly reduce the vegetation beds that are the preferred spawning habitat of Herring stocks in some locations.	(Burdick and Short, 1999)
Aquaculture	The infrastructure and activities associated with oyster cultivation has been shown to reduce the density of eelgrass in known Herring spawning areas. In addition, eggs may be deposited on aquaculture gear.	The impacts of reduced density in eelgrass beds means less spawning habitat is available. Eggs deposited on aquaculture gear may be at greater risk of desiccation or exposure to toxic compounds, depending on how the gear is treated.	(Rooper and others, 1999; Rumrill and Poulton, 2004; Schlosser and Eicher, 2012; Steinfeld, 1971)

Chapter 3. Ecosystem Considerations

3.1 Forage Role of Herring

California policy considers small pelagic fish such as Herring to be "forage fish" because they provide an important food source for upper- and mid-trophic level predatory fish, marine mammals, and seabirds. Typically, forage fish feed near the base of the food chain, often on plankton. By serving as forage for higher trophic levels they provide an energetic link between primary producers and predators at the tops of food chains.

In the greater CCE, Herring, along with juvenile rockfishes; Northern Anchovy, *Engraulis mordax*; krill; and Market Squid, *Doryteuthis opalescens* are forage species with the highest number of documented predators (Szoboszlai and others, 2015). The CCE is an eastern boundary current upwelling system off the West Coast of the United States, extending from the Straight of Juan de Fuca in the north to the Mexican border in the south. The magnitude of Herring's role as forage in the central CCE, which spans roughly from Crescent City Harbor to Point Conception, and is near the southern end of their eastern-Pacific range, is less clear. Herring from San Francisco Bay are thought to migrate to Monterey Bay during the summer (Moser and Hsieh, 1992), and this area provides a feeding ground for a number of predators, including Humpback Whales and Harbor Seals (Calambokidis and others, 2000; Eguchi and Harvey, 2005). Spawning aggregations, however, are likely to provide a seasonally important pulse for local predators, and the accumulated Herring and their eggs have been shown to provide important feeding grounds for migratory birds (Bishop and Green, 2001; Lok and others, 2008).

Herring's high fecundity and fast growth rate allows the species to take advantage of favorable oceanographic conditions, and stocks may exhibit large cyclical fluctuations in abundance, with stock sizes changing by orders of magnitude. While oceanographic conditions affect this variability, and forage fish stocks are generally able to recover rapidly when environmental conditions improve (Beverton, 1990), fishing can potentially exacerbate natural declines (Essington and others, 2015).

Because of the key role forage stocks play in transferring energy up the food chain, overfishing during declines has ecological implications beyond the sustainability of the target stock (Bakun and others, 2009). Decreases in forage fish populations have been identified as drivers of diet shifts and reduced productivity in predator populations, particularly seabirds (Becker and Beissinger, 2006; Crawford and others, 2007; Sunada and others, 1981). Ecosystem modeling has shown that the CCE is relatively more resilient to the effects of harvest on forage species than other upwelling systems due the presence of additional species that provide forage at some point in their life cycle (Smith and others, 2011). However, management safeguards may be needed to reduce the impacts of fishing on the ecosystem during periods of low productivity (Chapter 7, Appendix F).

3.2 Oceanic and Environmental Processes

Within the CCE, variability in several oceanographic processes can affect coastal and nearshore productivity, and in turn California's Herring spawning and rearing areas. For example, oceanic temperature and effects from regional climate processes co-vary with local conditions within San Francisco Bay to affect Herring spawning biomass negatively during warmer ocean periods (Sydeman and others, 2018). Herring biomass is thought to be positively correlated with upwelling (Reum and others, 2011), in which deep, cold, nutrient-rich water is brought to the surface by Ekman transport, which results from the strong, northerly winds that occur during late spring and early summer in the CCE. This nutrient-laden water results in increased plankton, which fuels production in coastal pelagic ecosystems (Rykaczewski and Checkley, 2008). Large-scale oceanographic processes in the Pacific Ocean such as the El Niño Southern Oscillation (ENSO) cycle, the North Pacific Gyre Oscillation (NPGO), and the Pacific Decadal Oscillation (PDO) can affect the extent, timing, and nutrient content of upwelled water (Chavez and others, 2002; Checkley and Barth, 2009).

3.2.1 Pacific Decadal Oscillation

The PDO reflects periodic changes in North Pacific SST that occur at longer temporal scales (~25 years). PDO values fluctuate between positive values, which suggest warmer, less productive conditions, and negative values, which indicate cooler, more productive conditions in the North Pacific (Figure 3-1). The PDO index was primarily positive ("warm") between 1977 and 1998, but switched to a negative ("cool") cycle in the late 1990s, which lasted through 2014. Shifts in PDO may provide some explanation for the cyclical patterns of Herring abundance observed in British Columbia over the last seven decades (Thompson and others, 2017).

3.2.2 North Pacific Gyre Oscillation

The NPGO signals fluctuation in sea surface height associated with changes in the circulation of the North Pacific Subtropical and Alaskan Gyres. NPGO has been found to correlate with fluctuations in salinity, nutrients, chlorophyll, and variety of zooplankton taxa, all of which are known to affect Herring productivity (Di Lorenzo and others, 2008). Fluctuations in the NPGO are driven by regional and basin-scale variations in wind-driven upwelling and advection, which control salinity and nutrient concentrations. Nutrient fluctuations drive planktonic ecosystem dynamics, and this is likely to affect species at higher trophic levels (Black and others, 2010). A positive NPGO index (Figure 3-1) is correlated with upwelling that begins earlier in the season in central California, which leads to a more productive planktonic ecosystem throughout the spring and summer and likely improves the survival of larval Herring.

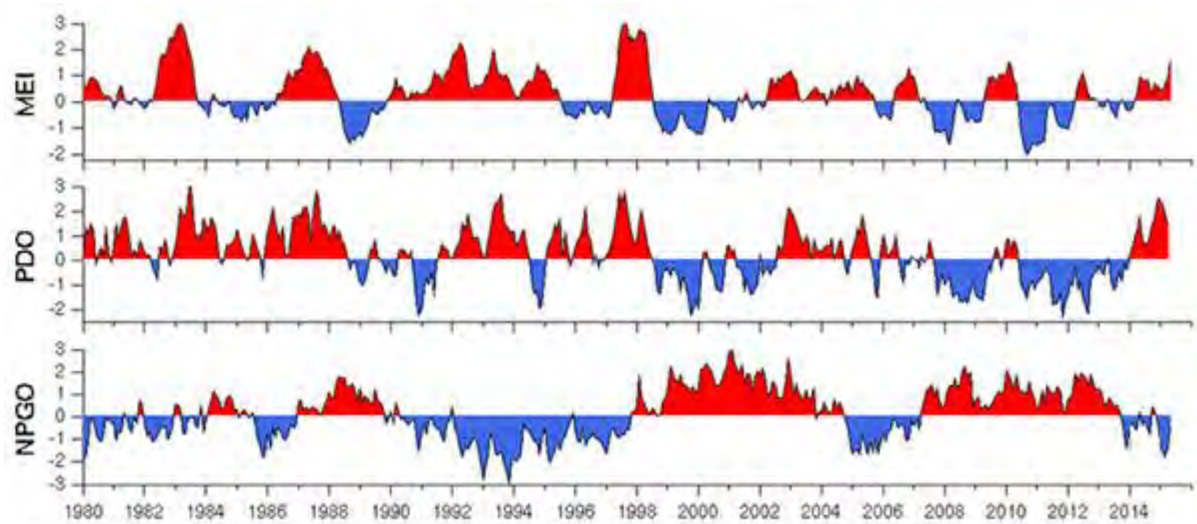

Figure 3-1. The Multivariate ENSO Index (MEI), PDO index, and NPGO between 1980 and 2016. Red MEI values denote El Niño (warm, low productivity) conditions and blue values denote La Niña (cool, more productive) conditions. Red PDO values are associated with warm regimes and blue values are associated with cold regimes. Red NPGO values are linked to earlier/greater upwelling, while blue values denote periods of lower/later upwelling.

3.2.3 El Niño Southern Oscillation Cycle and Herring Stocks

The ENSO cycle, which is measured using the Multivariate ENSO Index (MEI) (Figure 3-1), is the major mode of climate variability in the equatorial Pacific and can have major impacts throughout the Pacific Basin and the CCE. Strong El Niño events occurred in 1982-83, 1992–94, 1997–98, and 2015-16 (Jacox and others, 2016), and had noticeable negative impacts on the San Francisco Bay Herring population. For example, estimates of stock abundances have dropped sharply during or just after those events. Strong El Niño conditions result in warmer and more nutrient-poor conditions, which in turn reduces oceanic productivity and prey availability and reduces survival rates, growth rates, and the condition factor of Herring, as demonstrated by below-normal weight and condition factor indices for San Francisco Bay Herring in those years (Section 2.9.4). Warmer local oceanic conditions in the fall (i.e. just prior to spawning season) may affect the timing and/or magnitude of spawning migrations into San Francisco Bay, resulting in lower biomass estimates from spawning surveys (Sydeman and others, 2018) (Section 3.2.4). During the 1997-98 El Niño, it was noted that many females were reabsorbing their eggs rather than spawning that season (California Department of Fish and Game, 1998). El Niño events may also affect the survival of eggs, larvae, or YOY Herring.

3.2.4 Understanding Local and Regional Environmental Indicators of Herring Productivity

It can be difficult to assess how the variation in Herring production is driven by large-scale oceanic conditions relative to local effects at spawning grounds

(Reum and others, 2011; Siple and Francis, 2016). A study examining correlations between environmental indicators at various scales and metrics of San Francisco Bay Herring population health (such as SSB, age structure, and condition index) was commissioned as part of the development of this FMP (Sydeman and others, 2018) (Appendix E). In addition to the large-scale MEI, NPGO, and PDO indices, a composite index known as the Multivariate Ocean Climate Indicators (MOCI) (García-Reyes and Sydeman, 2017), which couples the shared variation in basin-scale drivers with regional processes such as upwelling and local oceanic responses (e.g., temperature and winds), was also tested. Additional indicators include regional metrics of SST and salinity, as well as delta outflow.

Correlations between these indicators and the observed SSB were tested over two-time periods: (1) the entire period of data availability (1979-2016) and (2) the time period corresponding with an increase in the variance of Herring SSB (1991-2016). While none of the indices had significant correlations with SSB for the entire period, many were significantly correlated with SSB in the later period (Table 3-1). All significant indicators were correlated with the observed SSB three years later (lag 3), except NPGO, which was also correlated at a lag of 2 years. The variance explained in correlations between SSB and environmental indicators increased after 1990, suggesting that Herring became more sensitive to environmental variability after the 1990s, which corresponds with a regime shift that was observed in CCE at that time (Hare and Mantua, 2000).

Of the large-scale oceanographic indicators, all significantly correlated with SSB except MEI, suggesting that, while strong El Niño events have had severe impacts on Herring stocks, the index does not correlate with overall stock abundance over the long term. The correlations of SSB with the other indices suggest that, as expected, oceanic conditions that result in more upwelling, cooler water, and higher nutrient levels result in higher observed SSB two to three years later.

Table 3-1. Correlation between SSB and environmental indices from 1991-2016. Indicator months and lag in years, if applicable, are shown in parentheses. Only nominally significant correlations ($p < 0.05$) are shown (adapted from Sydeman and others (2018)).

Indicator (1991-15)	Spearman Rank Correlation (**ρ**) Between Indicator and Observed SSB
Midwater trawls temperature (Trawl T)	-
Midwater trawls salinity (Trawl S)	**ρ** = 0.48 (Aug-Oct, yr-3)
Sacramento River Delta outflow (Outflow)	**ρ** = -0.59 (Jul-Sep, yr-3)
Farallon Islands sea surface salinity (Far-SSS)	-
Buoy N26 SST (N26-SST)	**ρ** = -0.41 (May-Jul, yr-3)
MEI	-
PDO	**ρ** = -0.46 (Apr-Jun, yr-3)
NPGO	**ρ** = 0.45 (July-Sept, yr-2, yr-3)
MOCI	**ρ** = -0.46 (Jul-Sep, yr-3)

Some conditions, such as temperature, showed different significance patterns between the ocean and bay. This analysis found that the Trawl-T index collected as part of the Department's Bay Study Program (Chapter 6) was not significantly correlated with SSB, but SST at Buoy N26 (near the Farallon Islands) was. SST at the Farallon Islands is influenced by large-scale oceanographic processes and is representative of nearshore oceanic conditions in the central CCE, while the Trawl-T index is more reflective of local conditions and processes within the bay and greater estuary area.

In contrast, salinity in the San Francisco Bay (from the Trawl S index) was significantly correlated with SSB, while salinity at the Farallon Islands was not. This suggests that salinity within the bay (which is primarily affected by Delta outflows and runoff) may influence spawning behavior of adults or larval survival. Laboratory studies indicate higher survival of larvae at lower levels of salinity (Griffin and others, 1998). Delta outflow at a three-year lag was also significantly correlated with SSB, but the time of year (summer) and flow direction (negative) makes it difficult to interpret any ecological mechanism behind this correlation.

3.2.5 Anticipated Effects of Changing Oceanic Conditions on Herring

The MLMA directs FMPs to describe the likely effects of changing oceanic conditions on the target species. The CCE is already a highly variable marine ecosystem, and Herring are sensitive to these environmental changes. This section describes some of the likely impacts of climate change on Herring stocks in California, however, this list is by no means exhaustive.

3.2.5.1 Increased Variability

Changes in atmospheric and oceanographic forcing may alter the length of warm or cool states, and these changes may be most apparent at the southern end of a species' range (Di Lorenzo and Mantua, 2016; Walther and others, 2002). Since the early 1990s, environmental conditions off the coast of California have been more variable than in previous decades, with more rapid shifts between warm and cool conditions. This oceanographic variability has been reflected in the increasing variance of the spawning biomass of the San Francisco Bay Herring stock: the inter-annual coefficient of variation of the SSB was 30% between 1980–1989 versus 97% after 1990 (Sydeman and others, 2018). Oregon and Washington Herring stocks also experienced increased variability over this time period, though northern stocks in British Columbia and Alaska exhibited either stable or decreasing variability (Thompson and others, 2017).

3.2.5.2 Range Shifts

Gradual change in SST is expected to drive long-term, directional changes in species distributions, and thus, species abundance and community composition in any given location (Walther and others, 2002). Species that favor cool conditions, such as Herring, may experience range contractions as SST increases and the ecosystem shifts into a less productive warm regime (Cochrane and others, 2009). A shift in species distribution may also reduce fishing opportunities in San Francisco Bay, which has historically supported a large fishery.

3.2.5.3 Increased Storm Action

Climate change may result in increased frequency and intensity of large storm events, which may impact spawning habitat for Herring. For example, a large storm event in 1981 damaged subtidal vegetation beds in Richardson Bay. Prior to that, Richardson Bay was the primary spawning location in San Francisco Bay, but after 1981 the San Francisco Waterfront became the primary spawning area for over 10 years (Spratt, 1992).

3.2.5.4 Changes in Physical Traits

Changes in temperature may drive changes in phenotypic expression (physical traits) of fishes and invertebrates, with faster growth and younger age at maturity more commonly observed in warmer waters (Crozier and Hutchings, 2014; Gienapp and others, 2008). Herring stocks in colder climes exhibit larger body sizes, slower maturation, and higher maximum ages (Schweigert and others, 2002). Herring stocks in California may see increases in growth rate and corresponding decreases in maximum size and life span. These changes would have far-reaching implications for our ability to assess the health of the stock, which is largely done via comparisons to historical metrics. In addition to observing a loss of older age classes of fish and a reduction in size at age (both metrics that usually indicate overfishing), the SSB at a given abundance would be lower due to the smaller size and lower fecundity of each fish. Additionally, the current mesh size of gill nets is regulated to select Herring of a specific size, age, and maturity level, so fishermen may see reductions in catch rates if Herring size decreases.

3.2.5.5 Changes in Seasonal Timing

Climate change may influence the seasonal timing of processes that affect Herring biology. The timing of spawning varies with winter temperatures, with spawning occurring earlier in warmer areas (Haegele and Schweigert, 1985). In addition, changes in the NPGO can alter the timing of spring upwelling (Chenillat and others, 2012). Delays in upwelling can affect the timing and magnitude of spring plankton blooms and the subsequent food availability for larval and YOY Herring.

3.3 Ecological Interactions

3.3.1 Herring Prey Sources and Competition

During all life stages, Herring primarily feed on small planktonic organisms (Section 2.6). Juvenile Herring in shallow subtidal areas feed primarily on zooplankton (Fresh, 1981). In San Francisco Bay, tintinnids, which are single-celled microzooplankton, compose a large portion of larval Herring diet (Bollens and Sanders, 2004). Larval copepods have been found in the stomach contents of larval Herring, and juvenile Herring feed on a variety of micro-plankton (diatoms, protozoans, bivalve veligers, and copepod eggs, nauplii, and copepodites) (Purcell and Grover, 1990). Increased concentrations of copepods have been shown to increase the growth rates of Atlantic Herring (Kiørboe and Munk, 1986).

Herring continue to feed on plankton throughout their life cycle, relying on visual cues in feeding (Blaxter and Holliday, 1963). Prey items selected by Herring change with their growth and geographic distribution. Krill become the primary food item for adult Herring as they move into offshore pelagic habitats. Foraging can have strong local effects on zooplankton community structure (Blaxter and Hunter, 1982).

Herring compete with a number of organisms for food during their life cycle. Although this has not been extensively studied, some data are available. Herring and Pacific Sardine share many of the same feeding grounds and exploit some of the same prey (McFarlane and others, 2005), although Pacific Sardine are exclusively filter-feeders and have a range that extends further south. Schweigert and others (2010) did not find strong evidence of Pacific Sardine competition as a factor in Herring abundance. Herring compete with juvenile and sub adult Coho Salmon, *O. kisutch*, for food in the shallow sublittoral habitat (Fresh, 1981) or for krill in the offshore pelagic habitat (Fresh and others, 1981). A similarity in diets of YOY Walleye Pollock, *Gadus chalcogrammus,* and Herring indicates a potential for competition between those species, and competition between or predation by juvenile hatchery Pink Salmon, *O. gorbuscha,* on Herring juveniles may have limited the recovery of a Herring stock in Prince William Sound (Deriso and others, 2008). Herring larvae compete with some of the soft-bodied zooplankton (medusae) for microplankton (Purcell and Grover, 1990).

3.3.2 Predators of Herring

All life stages of Herring are a food source for many species of birds, fish, invertebrates, and marine mammals in the CCE (California Department of Fish and Game, 2015; Rice and others, 2011; Schweigert and others, 2010; Womble and Sigler, 2006), and thus provide an important trophic linkage between predator health and the bottom-up processes that influence oceanic productivity (Section 3.1). Changes in abundance and age structure of forage species can lead to changes in growth, reproduction, and behavior of predators, including important recreational and commercial species as well as threatened and endangered fish, marine mammals, and sea birds (Pikitch and others, 2012). In the CCE Herring were found to be the fourth most commonly consumed prey group, behind rockfishes, Northern Anchovy, and krill (Szoboszlai and others, 2015). Predation is particularly high during spawning when adult fish and eggs are concentrated and available in shallow areas, and predation during spawning is a significant cause of natural mortality for Herring (Bayer, 1980; Haegele and Schweigert, 1985; Hardwick, 1973) (Section 3.8).

3.3.2.1 Predation on Herring Eggs

Herring ranked second in importance as a prey source for seabirds in a meta-analysis of predator-prey relationships in the CCE (Szoboszlai and others, 2015). At least 33 species of birds are known to feed upon Herring eggs (Table 3-2), and Herring eggs may provide an important source of dietary nutrients for migrating birds in San Francisco Bay. Glaucous-winged gulls, *Larus glaucescens,* appear to be dominant bird predators on eggs deposited within the intertidal zone in some areas (Norton and others, 1990). Two species of scoters were found to alter movement patterns in response to Herring spawning events in British Columbia in order to feed on Herring roe (Lok and others, 2008). Non-avian predators on Herring eggs include sturgeon, *Acipenser* spp., Surfperch (family Embiodocidae), silversides (family Atherinopsidae), and crabs (family Cancridae) (Hardwick, 1973).

Table 3-2. List of observed predators of Herring spawn (Bayer, 1980; Weathers and Kelly, 2007). Bold indicates species that also eat adult Herring.

Predators of Herring Spawn	
American Coot (*Fulica americana*)	Lesser Scaup (*A. affinis*)
American Widgeon (*Anas americana*)	Long-tailed Duck, formerly Oldsquaw (*Clangula hyemalis*)
Barrow's Goldeneye (*Bucephala islandica*)	Mallard (*Anas platyrhynchos*)
Black Brant (*Branta bernicla nigricans*)	Mew Gull (*L. canus*)
Black Scoter (*Melanitta americana*)	Northern Pintail (*A. acuta*)
Bonaparte's Gull (*Chroicocephalus philadelphia*)	Horned Grebe (*Podiceps auratus*)
Brandt's Cormorant (*Phalacrocorax penicillatus*)	Pelagic Cormorant (*P. pelagicus*)
Bufflehead (*B. albeola*)	Red-breasted Merganser (*Mergus serrator*)
Canvasback (*Aythya valisineria*)	Redhead (*A. americana*)
Common Goldeneye (*B. clangula*)	Ring-billed Gull (*L. delawarensis*)
Common Loon (*Gavia immer*)	Ruddy Duck (*Oxyura jamaicensis*)
Eurasian Wigeon (*Mareca penelope*)	Surf Scoter (*M. perspicillata*)
Glaucous-winged Gull	Western Grebe (*Aechmophorus occidentalis*)
Greater Scaup (*Aythya marila*)	Western Gull (*L. occidentalis*)
Harlequin Duck (*Histrionicus histrionicus*)	White-fronted Goose (*Anser albifrons*)
Hooded Merganser (*Lophodytes cucullatus*)	White-winged Scoter (*M. deglandi*)

3.3.2.2 Predation on Larval Herring

Herring larvae are preyed upon primarily by invertebrates (Arai and Hay, 1982; Blaxter and Holliday, 1963; Hourston and others, 1981; Moller, 1984; Purcell and others, 1987), including jellyfish (*Sarsia tubulosa* and *Aequorea victoria*), and comb jellies. *A. victoria* is a significant predator for a short period, consuming yolk sac larvae (12 mm) (0.5 in) with limited swimming ability. Small Surfperch, young salmon, amphipod crustaceans and arrowworms (Chaetognatha) have also been identified as predators on larval Herring (Stevenson, 1962).

3.3.2.3 Predation on Herring Adults by Fish, Birds, and Marine Mammals

A wide variety of fish, bird, and marine mammal species prey on Herring juveniles and adults in the CCE (Table 3-3) (Szoboszlai and others, 2015). Herring are more important to predators in British Columbia and Alaska, where Herring are generally more abundant, and many of the observed predator-prey interactions were from studies in coastal British Columbia (Szoboszlai and others, 2015). Table 3-3 describes the observed percentages of Herring in predator diets from studies near San Francisco Bay.

Many of these predators listed in Table 3-3 are opportunistic feeders (Emmett and others, 1986; Rosenthal and others, 1988), suggesting that none of these species are dependent on Herring alone. However, the diet composition data in Table 3-3 are primarily from studies conducted in the summer and may not reflect winter diet compositions when Herring migrate and aggregate to spawn. Forage fish predators often rely on specific locations where forage abundance may be high for a short period of time, such as near breeding areas (Hilborn and others, 2017). Diet data in winter are extremely limited due to logistical constraints on sampling, but winter data for central California that do exist suggest the potential for strong seasonal dependencies. The best winter predator diet data on Herring exists for Chinook Salmon, *O. tshawytscha*, in the GOF, just outside San Francisco Bay (Table 3-4). Herring are dominant in salmon diet when salmon were collected from coastal Herring holding areas during winter (Merkel, 1957). Salmon diets contained 49% Herring (by mass) from February-March; when averaged over the ten months of the study, Herring made up 13% of salmon diet (Merkel, 1957). Herring in the winter diet of salmon peaked at roughly 20% in a similar study in the early 1980s (Thayer and others, 2014).

Table 3-3. Known predators of adult Herring from the CCE (Szoboszlai and others, 2015). When available, the average percentage of Herring observed in predator diets is also reported. Bold indicates species from central or northern California. Note, studies are primarily from April-September, and do not reflect diet compositions in winter during Herring spawning season, when fish are densely concentrated near spawning areas.

Fish		Marine Mammal		Bird	
Spiny Dogfish (*Squalus acanthias)*	29%	Humpback Whale (*Megaptera novaeangliae)*	13%	Caspian Tern (*Hydroprogne caspia*)	7%
Pacific Hake adults (*Merluccius productus*)	11%	Northern Fur Seal (*Callorhinus ursinus)*	7%	Common Murre (*Uria aalge*)	7%
Black Rockfish (*Sebastes melanops)*	10%	Harbor Seal (*Phoca vitulina)*	5%	Rhinoceros Auklet (*Cerorhinca monocerata*)	6%
Chinook Salmon	9%	California Sea Lion (*Zalophus californianus)*	4%	Double-crested Cormorant (*Phalacrocorax auratus*)	2%
Coho Salmon	9%	Fin Whale (*Balaenoptera physalus)*	2%	Marbled Murrelet (*Brachyramphus marmoratus*)	2%
Jack Mackerel (*Trachurus symmetricus)*	2%	Harbor Porpoise (*Phocoena phocoena)*	2%	Least Tern (*Sternula antillarum*)	<1%
Pacific Hake juv.	1%	Sperm Whale (*Physeter macrocephalus)*	2%	Cassin's Auklet (*Ptychoramphus aleuticus*)	<1%
Sablefish (*Anoplopoma fimbria)*	1%	Common Dolphin (*Delphinus delphis)*	<1%	Sooty Shearwaters (*Ardenna grisea)*	<1%
Arrowtooth flounder (*Atheresthes stomias)*		Dall's Porpoise (*Phocoenoides dalli)*		Ancient Murrelet (*Synthliboramphus antiquus*)	
Bat Ray (*Myliobatis californica)*		Gray Whale (*Eschrichtius robustus)*		Arctic Loon (*Gavia arctica*)	
Blue Shark *(Prionace glauca)*		Orca Whale (*Orcinus orca)*		Bonaparte's Gull	
Chum Salmon *(O. keta)*		Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens)*		Brandt's Cormorant	
Copper Rockfish (*S. caurinus)*		Sei Whale (*Balaenoptera borealis)*		California Gull (*L. californicus*)	
Cutthroat Trout (*O. clarkii)*		Steller Sea Lion (*Eumetopias jubatus)*		Common Merganser (*M. merganser*)	
Gray Smoothhound (*Mustelus californicus)*				Glaucous-winged Gull	
Jumbo Squid (*Dosidicus gigas)*				Mew Gull	

Lingcod				Pelagic Cormorant	
Pacific Cod (*Gadus microcephalus*)				Pigeon Guillemot (*Cepphus columba*)	
Shortspine Thornyhead (*Sebastolobus alascanus*)				Red-breasted Merganser	
Soupfin Shark (*Galeorhinus galeus*)				Western Grebe	
Yelloweye Rockfish (*S. ruberrimus*)				Western Gull	
Yellowtail Rockfish (*S. flavidus*)					

Table 3-4. Herring in predator diets in California, spatially and temporally focused on localized data for Herring spawning in San Francisco Bay. The CCE includes Monterey Bay and the GOF. For GOF diet, percentage of Herring in the diet is indicated by an average value with range in parentheses if data from more than one study was available (Table F-2, Appendix F).

Herring predator	CCS summer diet[1]	Summer California diet	Winter California diet	GOF (Sep-Dec) diet	GOF (Oct-Mar) diet	GOF-Monterey Bay (Dec-Mar) diet	GOF (Feb-Mar) diet	GOF (Mar-Apr) diet
Chinook Salmon	9%	4%	27%	3% (1-5%)	16% (5-27%)	29% (10-49%)	29% (10-49%)	24% (9-39%)
Humpback Whale	~13%		~19%	~5%		~33% (26-40%)		
Common Murre	7%	0%	6%		20% (12-28%			28%
Harbor Seal	6%	8%	1%					
Pacific Hake	11%	7%						
Rhinoceros Auklet	6%	1%	1%					

Herring are vulnerable to seabird predation in the shallow water embayments typical of most spawning grounds. Flocks of Brandt's and Double-Crested Cormorants, Brown Pelicans, gulls, and loons are often observed diving on adult Herring schools during spawning season in Tomales Bay and San Francisco Bay. Terns are likely consumers of Herring YOY in the summer.

San Francisco Bay is near the southern limit of the Herring range, and as a result, Herring are more prominent in predator diets in the northern CCE. The amount of marine mammal predation on California Herring stocks has not been documented, but Herring are likely one of many important prey sources. As an example, California Sea Lions specialize in feeding on schooling, open water fishes, and are often observed in large numbers during spawning events feeding directly from commercial fishing nets and spawning aggregations.

3.3.3 Other Forage Sources for Predators of Herring

The CCE is more resilient to fluctuations in forage fish abundance than other upwelling systems because many species make up the mid trophic levels that link primary producers to secondary and tertiary consumers. Other forage species in central California include other small pelagic fishes such as Pacific Sardine and Northern Anchovy; invertebrates such as krill and Market Squid*;* juvenile rockfish, *Sebastes* spp.; and to a lesser extent juvenile North Pacific Hake, *Merluccius productus;* and sanddabs, *Citharicthys* spp. (Brodeur and others, 2014; Szoboszlai and others, 2015). Some of these species are consumed year-round, while other species are more important in winter (when Herring are concentrated for spawning and thus particularly important as prey).

Large fluctuations in abundance of major forage species in the CCE can potentially have consequences for Herring's role as forage in that system (Appendix F). Declines in both Pacific Sardine and Northern Anchovy, if persistent, may elevate the importance of other forage species, like Herring, within the diet of CCE predators. In general, Pacific Sardines thrive during warm water regimes and decline in cool water periods, and Northern Anchovy show an alternate trend. After reaching a recent year peak of about one million metric tons in 2006, the Pacific Sardine biomass dropped to an estimated 86,586 metric tons (190 million lb) in 2017[2], resulting in a closure of the directed large-scale fishery during the 2015-19 period. Northern Anchovy biomass fluctuates (MacCall and others, 2016). The sedimentary deposition record from the Santa Barbara Basin clearly indicates lengthy episodes of disappearance or near-disappearance of Northern Anchovy and Pacific Sardine prior to western settlement of the West Coast and large-scale fishing (Baumgartner and others, 1992), and it is likely that predator populations withstood those fluctuations.

3.4 Incorporating Ecosystem Considerations into Herring Management

In 2012, the Commission adopted a forage species policy that recognizes the importance of forage species to the marine ecosystem off California's coast and intends to provide adequate protection for forage species through precautionary and informed management[3]. One of the goals in developing this FMP was to provide management recommendations for Herring that take into account their role as a forage species based on the best available science. While the majority of fish stocks around the world are managed using indicators that describe the health of the target stock, there have been increasing calls to

[2] https://www.pcouncil.org/2017/04/47571/council-votes-to-close-pacific-sardine-fishery-for-third-year-in-a-row/

[3] California Fish and Game Commission. Forage Species Policy. Adopted Nov 7, 2012. Retrieved Feb 1, 2019 from http://www.fgc.ca.gov/policy/p2fish.aspx#FORAGE

incorporate indicators that provide information on ecosystem structure, function, and health into fishery management frameworks. Section 7.7.2 describes how ecosystem status assessment is incorporated into the management strategy for Herring.

3.4.1 Utilizing Environmental and Biological Indicators Improve Forecasting Ability

Weak to non-existent stock-recruitment relationships (in which the size of the population provides little-to-no information on the number of recruits produced) have made estimation of current stock size and forecasting for dynamic species like Herring very difficult. However, because small pelagics are so responsive to environmental conditions, it may be possible to incorporate environmental indicators along with traditional metrics of stock health such as indices of recruitment and abundance to improve our ability to predict stock sizes (Tommasi and others, 2017). The correlations identified in Section 3.2.5 between environmental indicators and SSB suggest promising pathways for improving our ability to predict Herring stock abundance. This research formed the basis for the development of a new forecasting model (Section 7.6.2).

Chapter 4. The Fishery

Herring stocks in California support commercial fisheries for Herring roe products, bait, and fresh fish. Since 1973, landings of Herring have been dominated by the roe fishery, which targets Herring just prior to spawning when they come into bays and estuaries each winter (Spratt, 1992). At its peak this fishery was one of the largest and most commercially valuable in California, reaching landings of more than 12,000 tons (11,000 metric tons) and an ex-vessel value of almost $20 million, but has since declined due to lower demand and competition from other Herring fisheries. This chapter describes the commercial and recreational fisheries for Herring in California.

4.1 Historical Fishery

Herring have been fished for thousands of years as they move into shallow bays and estuaries in large numbers each winter to spawn. Herring are relatively easy to catch and have been an important seasonal source of winter protein for various coastal indigenous peoples. Archeological evidence suggests that humans along the west coast of North America have been catching Herring for at least 8,000 years (Thornton and others, 2010), and it is hypothesized that they were the most utilized fish species by communities of the coastal areas of the Pacific Northwest during the last several thousand years (McKechnie and others, 2014). Data suggest the indigenous fishery of Point Reyes in the homeland of the Coast Miwok people was directed toward the acquisition of mass-captured forage fish from the families Clupeidae, Atherinopsidae, and Engraulidae, in addition to Embiotocidae (Sanchez and others, 2018). Herring are still a species of cultural importance to some California Native American Tribes.

Herring have been harvested in California for a variety of commercial purposes since at least the mid-1800s (Spratt, 1981). The Department began recording annual landings in 1916 (Figure 4-1). Prior to 1916, annual catches were low, with most of the fish sold fresh. Small amounts also were salted, smoked, pickled, or canned for human consumption. As ocean sport fishing increased, more Herring were used for bait. Between 1916 and 1919, Herring were also harvested for canning and the production of fish oil and meal (Scofield, 1918). In 1918 the catch reached roughly 8 million pounds (4 thousand metric tons), mostly from Tomales and San Francisco Bays. The Reduction Act of 1919 prohibited the reduction of whole fish of any species into fishmeal except by special permit. Permits were not issued for Herring, effectively ending the first period of peak landings.

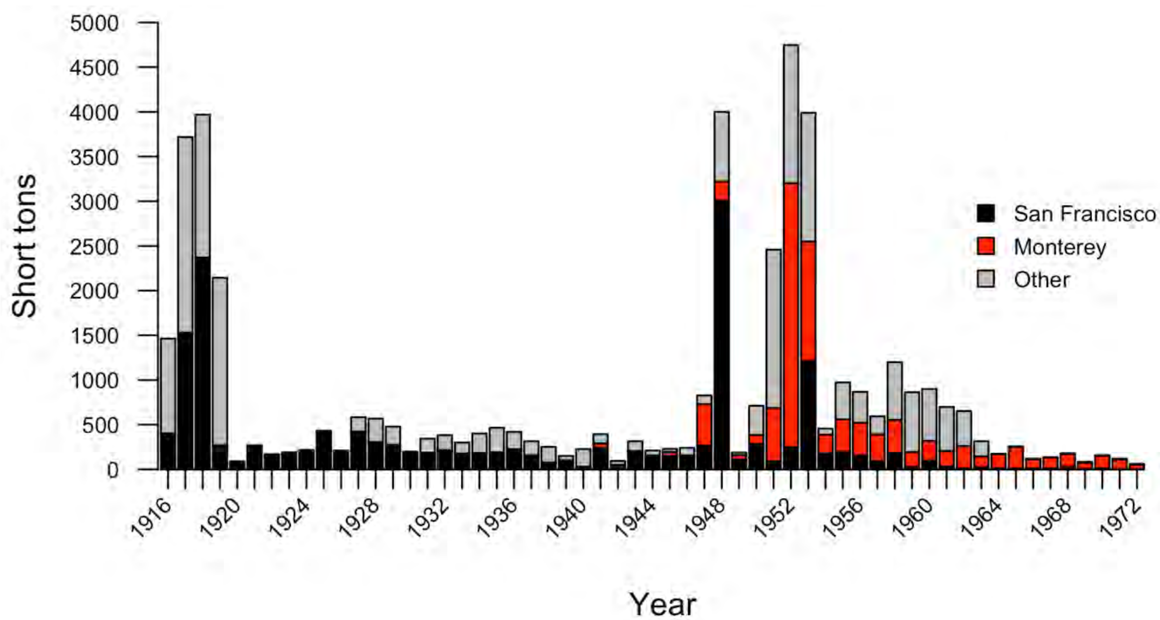

Figure 4-1. California historic Herring landings in San Francisco Bay (black), Monterey (red), and other locations (grey) from 1916-1972.

Between 1920 and 1946, there was little canning of Herring, though moderate quantities continued to be sold for fresh consumption, for salting and smoking, and for bait. The second peak in landings occurred in the late 1940s and early 1950s in an effort to replace Pacific Sardine. However, canned Herring was less desirable than Pacific Sardine and landings declined (Miller and Schmidtke, 1956). Some canning for human consumption continued and an unsuccessful effort was made to develop a pet food market for canned Herring. Landings, primarily for bait in the Monterey area, continued at low levels until the beginning of the sac-roe Herring fishery in the early 1970s.

4.2 Herring Fishery for Sac-Roe

In 1973, Japan began importing Herring roe from California. The traditional product from this fishery, kazunoko, is the skein (or sac) of eggs (roe) removed from the females, which is processed and exported for sale in Japan as a delicacy. Regulated harvest of Herring roe in California has occurred every year since 1973 except for a one-season fishery closure in 2010, and a complete lack of effort during the 2018-19 season. The sac-roe fishery is limited to California's four largest Herring spawning areas: San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor. San Francisco Bay has the largest spawning population of Herring and produces more than 90% of the state's Herring catch (Figure 4-2).

The other stocks in California historically supported smaller roe fisheries, and the Department monitored landings and conducted surveys in some locations. Tomales Bay was intensively monitored annually through the 2005-06 season, the stock in Humboldt was monitored intermittently, and the Crescent

City Harbor stock has never had a spawning assessment survey. The Department established fixed quotas for these northern management areas, which have remained in place for a decade or longer. Fixed quotas are set to allow fishing opportunities, but Herring have not been fished in the northern management areas since 2002 in Crescent City Harbor, 2006 in Humboldt Bay, and 2007 in Tomales Bay. Permit renewals have also fallen over the past several years, reducing the fleet capacity in these areas.

Throughout this time whole Herring have also been harvested for the bait and fresh fish markets (Section4.4). The sections below describe each sector of the modern Herring fishery (Appendix G).

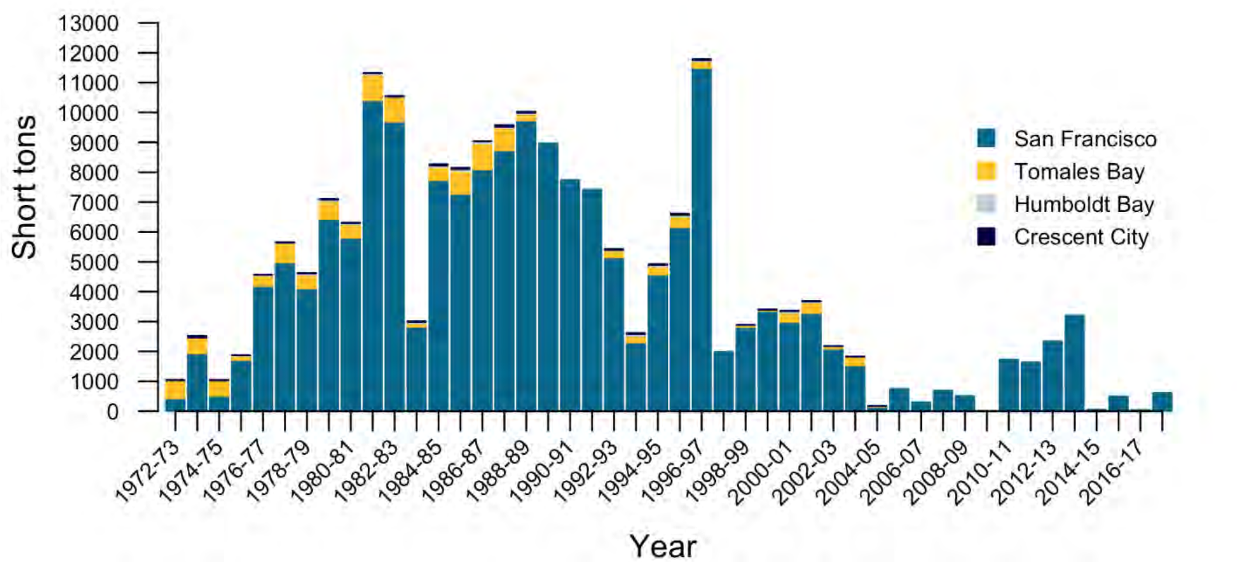

Figure 4-2. California Herring landings by area in short tons between 1973 and 2017 in San Francisco Bay (blue), Tomales Bay (yellow), Humboldt Bay (gray), and Crescent City Harbor (black). The commercial fishery was closed for the 2009-10 season. Note that this figure does not include landings from the ocean waters fishery (Monterey Bay).

4.2.1 San Francisco Bay

4.2.1.1 Controlled Expansion and Creation of Gill net Platoons (1970s)

When the sac-roe fishery began in the winter of 1972-73, emergency legislation was passed by the California State Legislature (Legislature) to set conservative quotas for three years in order to give the Department time to assess the population and develop a protocol for conducting surveys and setting quotas. During the 1975-76 season the Commission began issuing permits and setting annual quotas based on biomass surveys. As Department biologists learned more about the size of the San Francisco Bay Herring stock through annual surveys, both quotas and the number of permits were increased to provide additional access to the fishery.

Initially there were few regulations for gear type, and the fleet fished gill net and round haul (seine) gear, which consisted of lampara and purse seine.

The legalization of set gill nets occurred in 1977 (previously, only drift gill nets were allowed), which made gill net gear more desirable and resulted in an increase in gill net permits. The Commission also stopped issuing new round haul permits for the California Herring fishery, with the intent of converting the sac-roe fishery entirely to gill net. Round haul gear had a tendency to catch smaller, younger, lower value fish, and it was suspected that seiners increased mortality in the fishery by catching and releasing Herring during roe percentage testing (Garza, 1996). Since permits were non-transferable, the round haul fleet declined gradually through attrition, and no further action was taken to remove round haul gear until the 1990s.

High prices for sac-roe caused rapid expansion of the fishery, and the fishing grounds in San Francisco Bay became congested. In the 1978-79 season the Commission divided the 220 gill net permit holders into two groups. Defined by permit number, these groups were known as the "Odd" and "Even" platoons. Each platoon was allocated a portion of the quota and allowed to fish during alternating weeks of the season. To further address concerns about congestion and high demand for Herring permits, the Commission issued permits for a three-week gill net fishery in December. Prior to this, commercial Herring fishing in San Francisco Bay had only been allowed January through March.

4.2.1.2 Stable Fishery (1980s)

By 1983, fishery participation was stable. There were 430 permits in San Francisco Bay, with the majority of them allocated to the three gill net platoons. Herring quotas continued to increase and reached 10,000 tons (9,074.4 metric tons) in the 1981-82 season. Following the strong El Niño event in 1982-83, stock size decreased, and the fishery saw a reduction in landings, but the stock recovered quickly and remained relatively steady until the early 1990s. Quotas during the 1980s were generally set with the intent to achieve an exploitation rate of approximately 15%, and landings remained high.

4.2.1.3 Stock Declines and Conversion to All Gill net Fleet (1990s)

The San Francisco Bay Herring stock declined during the 1992-93 season following a strong El Niño event. However, this decline coincided with record high prices so there was significant pressure to continue allowing a commercial fishery. The price per ton and landings reached record highs during the 1996-97 season, but in the following year abundance declined following another strong El Niño event. The stock showed signs of lower productivity, including smaller and younger fish.

In 1994, the Commission began to phase out round haul gear from the fishery. This was due to concerns about the reduction in older (age six and older) fish in the San Francisco Bay Herring stock. Regulations required seine operators to convert to gill net gear within five years, providing the ability to fish one CH permit in both platoons in exchange for a single round haul permit. All remaining round haul permits were converted to gill net permits by the 1998-99 season, and since that time, sac-roe has been taken commercially in San Francisco Bay by gill net only. The conversion from round haul to gill net gear resulted in an increase in the total number of permits to 457, which corresponded with 120 vessels in San Francisco Bay.

4.2.1.4 Precautionary Management (2000s into the early 2010s)

In response to the stock declines observed following the winter 1997-98 El Niño event, in 2003 a stock assessment and methodology review was conducted for the San Francisco fishery (Appendices C and I), and the quota-setting policy was changed with the aim of reducing exploitation rates from 15% to 10% or less. During this time, fishing effort in the San Francisco Bay Herring fishery has also decreased substantially due to declining prices, and in many years exploitation rates have been under 5%. In the 2010-11 season, the Commission, with support of industry representatives, eliminated the December fishery, and December permits were incorporated into the Odd and Even platoons. While this reduction in early season fishing pressure may have contributed to an increase in older age classes, Herring abundance exhibits a high degree of interannual variability. For example, a record high spawning biomass occurred in 2005-06, but was followed four years later (2009-10) by a fishery closure due to concerns over low estimated spawn stock biomass. This degree of variability highlights the importance of the Department's precautionary management approach.

4.2.2 Tomales and Bodega Bays

4.2.2.1 Expansion and Resulting Regulatory Changes

As in San Francisco Bay, commercial fishing for Herring sac-roe in Tomales Bay began in 1973 under a precautionary quota to give the Department time to assess the stock. A formal quota and limited entry system for Tomales Bay was established in 1974-75. The following year fishermen began fishing for Herring in outer Bodega Bay, north of the mouth of Tomales Bay. Herring have been observed to spawn in shallow areas of Bodega Bay, but the fishery targeted Herring in deeper water areas of the bay. Tomales and Bodega Bays were initially managed under separate permit systems until 1978-79 when they were combined into a single permit area with a cap of 69 permits. In the following years, a number of additional regulations were created to prevent conflicts between fishermen, recreational users, and residents. These included weekend fishing prohibitions, prohibition of round haul gear, and limits on the number and mesh size of gill nets (Appendix H). Beginning in 1979, Bodega Bay and Tomales permittees were also split into two platoons that fished alternate weeks to alleviate congestion and conflict on the fishing grounds. Between 1981 and 1983, Tomales-Bodega area Herring permittees were allowed to exchange their permits for available San Francisco Bay permits to further reduce congestion. This reduced the number of permits to 41, and later a cap of 35 permits was established for the Tomales-Bodega Bay fishing area. During this time, the platoon system in this area was also eliminated due to the reduction in permit numbers.

4.2.2.2 Stock Declines

The Tomales and Bodega Bays spawning stock had remained above 4,700 tons (4,300 metric tons) between 1973-74 and 1982-83, and the commercial fishery exploitation rate did not exceed 12% during that time. However, the spawning stock declined to 1,280 tons (1,160 metric tons) in 1983-84 following a strong El Niño event. The stock recovered in the following years, but the Tomales Bay permit area was closed to commercial fishing after a record low SSB estimate in 1988-89. The fishery remained closed for three years because the SSB did not exceed minimum thresholds required to support a fishery. Department staff hypothesized that Herring were displaced from Tomales Bay due to an ongoing drought. During the 1992-93 season, the six-year drought ended and a large, 4,072-ton SSB (3,695 metric tons) of Herring returned to Tomales Bay. Commercial fishing resumed under precautionary management measures that included a quota based on a 10% intended (target) harvest rate, an increase in minimum mesh size, and a reduction in the amount of gill net gear allowed per vessel (Appendix H).

Fishing was allowed to continue in Bodega Bay when Tomales Bay was closed. However, the outer Bodega Bay fishery was eventually closed during the 1993-94 season based on the concern that fishing activity in Bodega Bay intercepted potential Tomales Bay spawning stock and that an accurate estimate of the SSB in those areas could not be obtained as long as fishing was allowed in Bodega Bay.

4.2.2.3 Stable Biomass but Declining Market Access

Tomales Bay SSB estimates remained stable, although lower than they had been in the 1970s and 1980s, until the 1997-98 El Niño event. Following this event, Herring stocks statewide experienced a loss of older age classes and reduced growth rates. As a result, no fishing occurred during the 1997-98 season in Tomales Bay. In subsequent years, the stock began to recover, but fishery participation continued to decline due to market reasons. In 2006-07, only two vessels fished as a result of high operating costs and low market demand. This was the last year that commercial fishing occurred in Tomales Bay, and spawning biomass surveys were discontinued the following year due to limited Department resources.

4.2.3 Humboldt Bay and Crescent City

During the 1973-74 season, in response to demand from fishermen for a local commercial Herring fishery, the Legislature expanded its management authority to include Humboldt Bay. A 20-ton quota (18 metric tons) was established and a two-year population study was initiated to determine the status of Humboldt Bay Herring stock (Rabin and Barnhart, 1986). This study estimated the SSB in Humboldt Bay to be 372 tons (237 metric tons) in 1975-75, and 232 tons (210 metric tons) in 1975-76. After this study concluded, it was determined that the stock could support a 50-ton quota (45 metric tons) fishery, which was roughly 13% and 22%, respectively, of the two SSB estimates. Initially, six permits were issued for Humboldt Bay, but in 1977 the number of permits was reduced to four.

After the initial study, no population assessments were completed in Humboldt Bay until 1990. In 1982 the quota was increased to 60 tons (54 metric tons), however this change coincided with an El Niño event and landings were low that year. Landings increased the following year and generally stayed between 40 and 70 tons (36 and 64 metric tons) over the next 15 years, with the exception of the 1988 and 1993 seasons, the latter coinciding with another El Niño event. The quota was exceeded in some years due to the difficulty of monitoring and predicting catch levels.

Humboldt Bay's SSB was re-assessed during the 1990-91 and 1991-92 seasons and was estimated to be at 400 and 225 tons (363 and 204 metric tons), respectively. However, during the second-year weather conditions prevented timely observation of a large spawning event, so that year's survey was believed to be an underestimate (Spratt and others, 1992).

Between 2000-01 and 2006-07 the Humboldt Bay stock underwent annual spawning assessments. The estimated SSB showed high variability during those years, and in the final survey year, a record low biomass was observed. Fishermen reported that stocks had declined in Humboldt Bay since the late 1980s (California Department of Fish and Game, 2001), and fishing effort declined in the late 1990s and early 2000s, with only one permit being active in most years. The Humboldt Bay quota was only reached once after the 1997-98 El Niño. There was no fishing effort in the 2005-06 season by Humboldt Bay permittees. The low catches were attributed to a disproportionate amount of small Herring in the population, which could not be caught in the 2.25-in (57 mm) mesh nets (Mello, 2006).

Commercial Herring fishing in the Crescent City area has primarily targeted schools that spawn in Crescent City Harbor. Biomass has been estimated for individual spawning runs in Crescent City Harbor (California Department of Fish and Game, 1998), but no seasonal population estimates have been made for this stock. Anecdotal reports suggest that spawning activity can be intense, with large amounts of spawn deposited. Fishing in the Crescent City area began in 1972-73, and in the 1973-74 season a record high of 60 tons (54 metric tons) was landed. In 1977 a 30 ton (27 metric tons) quota was established for Crescent City Harbor, and four permits were issued. Since the 1983-84 season only three permits have been renewed annually.

No changes have been made to the regulations governing Herring fishing in the Humboldt and Crescent City permit areas since 1983. These areas did not have the same levels of participation that resulted in the competition and conflict experienced in the southern permit areas. Until the late 1980s, landings varied considerably from year to year. It is unknown if this reflects annual variability in stock abundance or fishing effort. However, from the late 1980s to the late 1990s, catch rates were stable, and the quota was exceeded in a number of years due to monitoring difficulties. Fishing effort in Crescent City declined in the early 2000s, and the last landings were made in 2002. At the time this FMP was being drafted, fishing had not resumed in either Humboldt Bay or Crescent City Harbor due to low market prices and lack of processing facilities.

4.3 Herring Eggs on Kelp Fishery

In 1965, a new market for California Herring opened when Japan began importing Herring eggs spawned on seaweed, known as kazunoko kombu, which was highly prized in Japanese markets. The Commission began accepting bids (in the form of a royalty per ton) for the right to harvest five tons (4.5 metric tons) of Herring eggs on seaweed (total product weight) in Tomales and San Francisco Bays (Spratt, 1981). The harvesting was done by SCUBA divers collecting primarily *Gracilaria* spp. and *Laminaria*. This fishery operated from 1966 to 1986, but the quota was never reached. Harvest of Herring eggs using suspended kelp rather than collection of native seaweed was first allowed in San Francisco Bay during the 1985-86 season under an experimental gear permit (Moore and Reilly, 1989), and this is still the current method of harvest used in the fishery.

To fish Herring Eggs on Kelp (HEOK), Giant Kelp, *Macrocystis pyrifera*, is suspended from rafts or cork lines in shallow areas for Herring to spawn. HEOK fishing does not result in mortality to adult Herring, as only the eggs are removed with the kelp once Herring spawning has concluded. Rafts and cork lines are positioned in locations where Herring spawning is expected to occur. Suspended kelp is left in the water until egg coverage reaches a marketable amount or spawning has ended. The product of this fishery is the egg-coated kelp blades, which are processed, graded by quality and exported to Japan. Giant Kelp does not occur in large quantities in the bays where Herring spawn, so kelp is typically harvested off central California and then transported to San Francisco Bay. The kelp begins to deteriorate within 8-10 days, so the location and timing of kelp suspension must be carefully considered to maximize the chance of coverage with eggs.

The method of HEOK fishing employed in California's is termed "open pound" because Herring (and other animals) can freely move in and out of the suspended kelp. This differs from the "closed pound" method, which is more commonly used in HEOK fisheries outside of California. In the closed pound method, fishermen hang kelp in floating net pens (pounds) and mature Herring are captured by purse seine and confined for several days until spawning occurs. The capture, transport, and confinement associated with the closed pound method has been shown to result in damage to the fish, including bruising, scale loss, and other injuries, and results in some mortality (Shields and others, 1985). Closed pound fishing has also been shown to increase rates of disease in confined Herring (Hershberger and others, 2001).

4.3.1 Evolution of the HEOK Fishery

In preparation for opening the HEOK fishery, Department biologists sampled landings from the experimental HEOK rafts during the 1987-88 season (Moore and Reilly, 1989). The study objectives were to determine the appropriate conversion rate between adult Herring spawning biomass and the weight of the eggs-on-kelp product, as well as to collect biological data and determine ongoing monitoring needs for a sustainable fishery. They found that 4.853 tons (4.403 metric tons) of Herring could produce 1 ton (0.907 metric tons) of eggs on kelp, which led to the development of a conversion factor of 0.206 to determine an equivalent amount of eggs-on-kelp produced by a given Herring spawning biomass.

When the HEOK fishery was established there was a desire to reduce the number of vessels in the sac-roe fishery. Sac-roe permit holders were allowed to transfer into the HEOK fishery, forfeiting their ability to participate in the sac-roe fishery for that season. The HEOK permit was classified as a gear transfer rather than a separate permit. There was a cap of 10 permit transfers annually into the HEOK fishery, and each HEOK permit was entitled to an individual quota equivalent to 1% of the total San Francisco Bay Herring quota, converted into "equivalent" eggs on kelp using the 0.206 conversion factor.

Historically, HEOK was a high value product, and landings remained relatively stable between the 1989-90 and 2003-04 seasons. Subsequently, HEOK effort and landings began to decrease. At the time of FMP development, HEOK landings had last occurred during the 2012-13 season. Primary factors for the decrease in effort are high operating costs, reduced market value, and reduction in demand. The fishing industry has also indicated that an increase in the number of marine mammal (sea lion and seal) interactions presents challenges to this fishery because marine mammals target schools that spawn around HEOK rafts, potentially damaging the kelp product.

4.4 Whole Fish

Prior to the start of the sac-roe fishery, a "bait" fishery for whole Herring existed in San Francisco Bay. In 1973-74, when Herring sac-roe permits were first issued, six of the permits were for bait and were not subject to the quota established by the Legislature (Spratt, 1981), but it was suspected that these bait fish entered the roe market (Spratt, 1992). The baitfish loophole was closed in 1975, and during the 1975-76 season, ten "special permits" were issued in San Francisco Bay and five in Tomales Bay for bait (whole fish). These permits were issued on a first come first serve basis, and fish were primarily taken using beach seine gear.

In 1979-80, the whole ('fresh') fish allocation in San Francisco Bay was modified so that a permittee had to possess a valid market order for Herring, not to exceed 500 lb (0.25 tons) per day. The whole fish season was also changed so that Herring could be taken between 02 November and 31 March, but closed during the sac-roe season to prevent Herring from being sold illegally into the roe market. Beginning in 1981 and continuing through 2013, separate 20-ton (85 metric tons) San Francisco Bay and 10-ton (9.1 metric tons) Tomales Bay whole fish quotas were allocated each season. Participation and landings of whole fish during this period were low.

Beginning in the 2013-14 season, regulations were modified to facilitate a local market for fresh Herring for human consumption. The separate quotas and restrictions on landing whole fish during the sac-roe fishery in Tomales and San Francisco Bays were eliminated to provide a pathway for participants in the gill net fleet to explore alternative local markets. Following this change, any portion of the gill net quota could be landed either for whole fish or sac-roe. The Department and Commission have recently been asked to consider allowing alternative gear (cast nets) to be used to catch Herring for the whole fish market. Innovation in this fishery, as new methods of take continue to evolve, may be explored through the use of experimental fishing permits (FGC §1022). See Section 4.7.4 for a discussion of market access to whole Herring, and Chapter 7 for management recommendations regarding gear innovation.

4.5 Ocean Waters Commercial Fishing

Commercial fishing for Herring in ocean waters (outside of Crescent City Harbor and Humboldt, Tomales and San Francisco Bays) occurred prior to the establishment of a sac-roe fishery (Section 2.2) and continued until 2009. The majority of landings came from Monterey during the summer months, though small amounts of landings were reported south of Monterey, and in the Eureka and Crescent City areas. In 1976, the Commission established a season from April 1 to September 30. Beginning in 1979, the season was extended to December 1. This was later changed to allow fishing from April 1 to November 30 from Pigeon Point, San Mateo County south to Monterey, and from April 1 to October 31 between Pigeon Point and the California-Oregon Border.

Between 2003 and 2008, the ocean commercial fishery landed approximately 36% of the overall California commercial Herring catch. During this period, six purse seiners participated in the ocean fishery and landings averaged 144 tons (131 metric tons) per year. After the 2008-09 San Francisco Bay stock collapse, the Commission implemented an emergency closure of the ocean waters fishery as a conservation safeguard. Beginning January 1, 2010, all directed commercial fishing for Herring in ocean waters was prohibited.

Herring are still caught incidentally in ocean waters by purse seiners targeting other coastal pelagic fish species, primarily in Monterey Bay. An incidental take of no more than 10% Herring by weight of any landing composed primarily of other coastal pelagic fish species or Market Squid may be landed. Herring typically make up a small percentage of any given vessel's overall catch and revenue. This incidental catch supplies markets for whole fish (bait), aquarium food, and animal feed.

4.6 Sport Fishery

Spratt (1981) noted the presence of a sport fishery for Herring in San Francisco Bay and the Noyo River estuary during the 1970s and early 1980s, and recreational catch of Herring has continued since that time. Fish are caught with hook and line, hoop nets, and cast nets, primarily from beaches, piers, jetties, and small skiffs during times when Herring spawning aggregations are easily accessible. Few data are available on recreational catch or effort. Fishing effort, however, is observed to be the highest in San Francisco Bay because of the number of spawning aggregations accessible by sport fishermen. Crescent City Harbor also provides limited access to recreational fishermen when Herring spawns occur. Historically, managers believed that recreational catch made up a small percentage of the total Herring landings due to the opportunistic nature of this fishery, no catch restrictions on recreational take of Herring were implemented. However, observations by Department staff suggest that landings have been growing in recent years, with reports of recreational anglers taking large amounts of Herring, estimated to be up to several thousands of pounds each, which has led to concern about the illegal commercialization of the recreational catch. See Section 4.7.6 for further characterization of the sport fishery, including socioeconomic considerations, and Chapter 7 (Section 7.8.7) for limits established under this FMP regarding the recreational take of Herring.

4.7 Socioeconomic Considerations

FMPs provide an opportunity to revise, update, and modernize fishery regulations. Many of the regulations that have been established in the Herring fishery over time were in response to the socioeconomic considerations for a much larger fleet. These included the development of a platoon system to eliminate vessel congestion on the fishing grounds, restrictions on the number of permits each participant could hold to maximize access, and permit caps to maintain the economic viability of the fleet. However, since the early 2000s, the Herring fishery has undergone significant changes, with declines in prices and quotas effectively reducing overall fishery participation. One of the primary goals of this FMP is to develop new regulations that help meet the needs of the modern fleet and associated fishery support businesses. This section describes the roles of these businesses in product offloading, processing, and pricing, as well as how changes in fleet composition since the early 2000s have prompted the need for a new permitting system. The current socioeconomic composition of the fleet is discussed, and consideration is given to how that composition might be impacted by the regulatory changes established under this FMP.

4.7.1 Product Offloading, Processing, and Pricing

The primary product from the modern commercial gill net fishery is sac-roe, which consists of the mature (ripe) egg skeins of gravid female Herring. Fishing operations target mixed schools of male and female fish, and thus both male and female Herring are caught in the gill nets. At the time of FMP development, 24 vessels were registered to permit holders, with an average reported vessel capacity of 20 tons (18 metric tons). When Herring vessels reach their maximum capacity (or when the spawning event is over), the boats leave the fishing grounds and return to port for offloading to licensed Herring buyers.

In the past, during the peak of fishing in San Francisco Bay, offloading sites and their associated infrastructure were situated at several locations around the bay, including the San Francisco Waterfront, Port of Oakland, and Sausalito. Multiple sites were necessary to prevent long waits for fishing vessels to offload. Currently, however, offloading, processing, and buying takes place only in San Francisco, with the majority of activity and associated infrastructure confined to the area of Fisherman's Wharf. During offloading, fish are pumped from the boat into holding containers (fish totes) and weighed using certified scales. Commercial landing receipts are completed and Herring buyers report the weight of Herring purchased to Department staff. This allows the Department to track the season's quota and predict when an individual platoon's quota might be reached. Department staff are regularly onsite to oversee offloading and collect samples from the commercial catch. This in-season tracking helps minimize the potential for quotas overages, and as a result the San Francisco Bay quotas have rarely been exceeded.

Licensed Herring buyers pay fishermen based on the percentage of ripe skeins in the catch. This is calculated from several random 10-kilogram (kg) samples per landing. Each fish sampled is sexed and ripe skeins are extracted, placed on a scale and weighed. The total weight of the ripe skeins is then divided by 10 kg, resulting in the roe percentage. San Francisco Bay roe percentages are typically 10% or higher, while Herring buyers in Eureka required roe percentages of at least 12% (K. Bates, personal communication). The roe percentage for San Francisco averaged 12 to 14% through the mid-90s, but has increased since the late 1990s. The ex-vessel price is based on minimum 10% yield and is adjusted for percentage points above the minimum (Figure 4-3). Despite increases in roe percentage, price per ton has declined since the late 1990s.

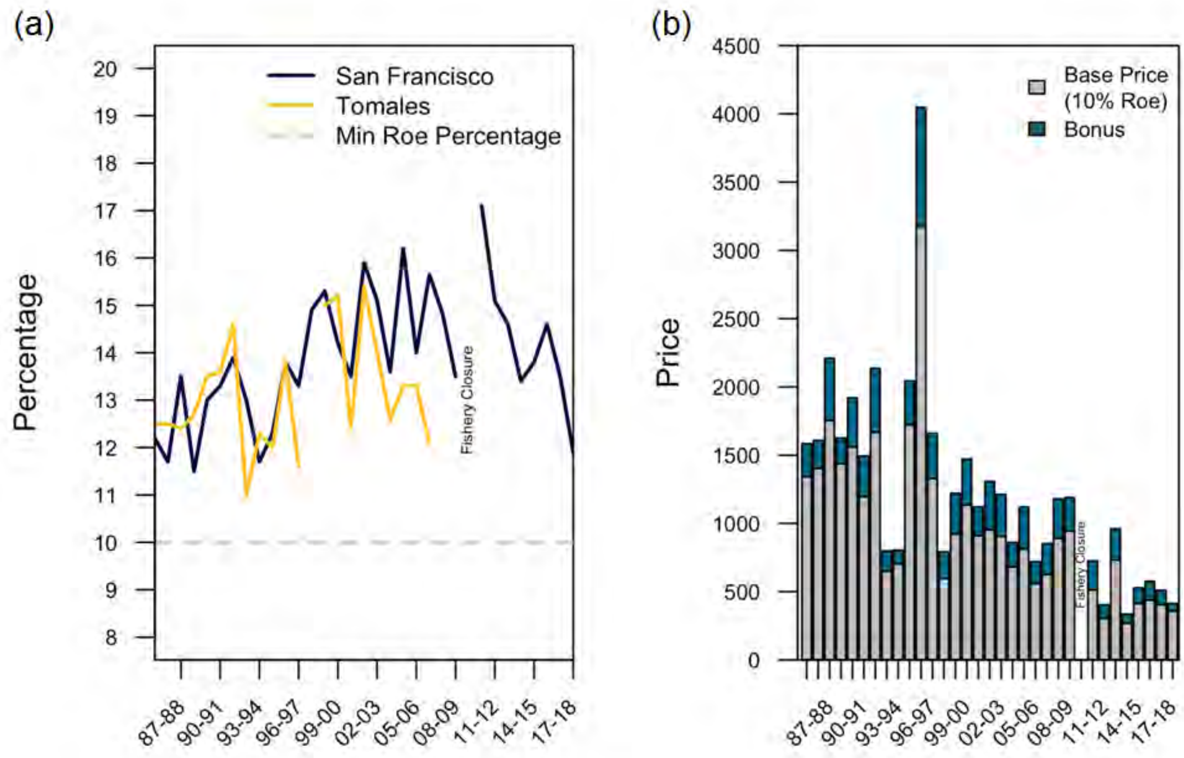

Figure 4-3. Roe percentage of gill net fishery (a) in San Francisco Bay (purple) and Tomales Bay (yellow) and pricing for the sac-roe fishery (b) including the base price (10% roe, grey) and bonus (blue).

Herring are iced and then trucked from the port of landing to a processing plant for skein removal, brining, and grading. Roe skeins are graded by size, color and shape, and then packed for export to the primary market in Japan. Brined skeins are leached in freshwater overnight and served with condiments or as sushi. They are associated with good luck, and typically eaten in New Year's celebrations or given as gifts. High demand for kazunoko in Japan resulted in high ex-vessel prices for Herring roe between the 1970s and the 1990s, and the Herring fishery was one of the most valuable in California, reaching almost 20 million dollars in ex-vessel value at its peak (Figure 4-4). However, a combination of low prices and reduced quotas has resulted in a much lower total value for the fishery since the early 2000s.

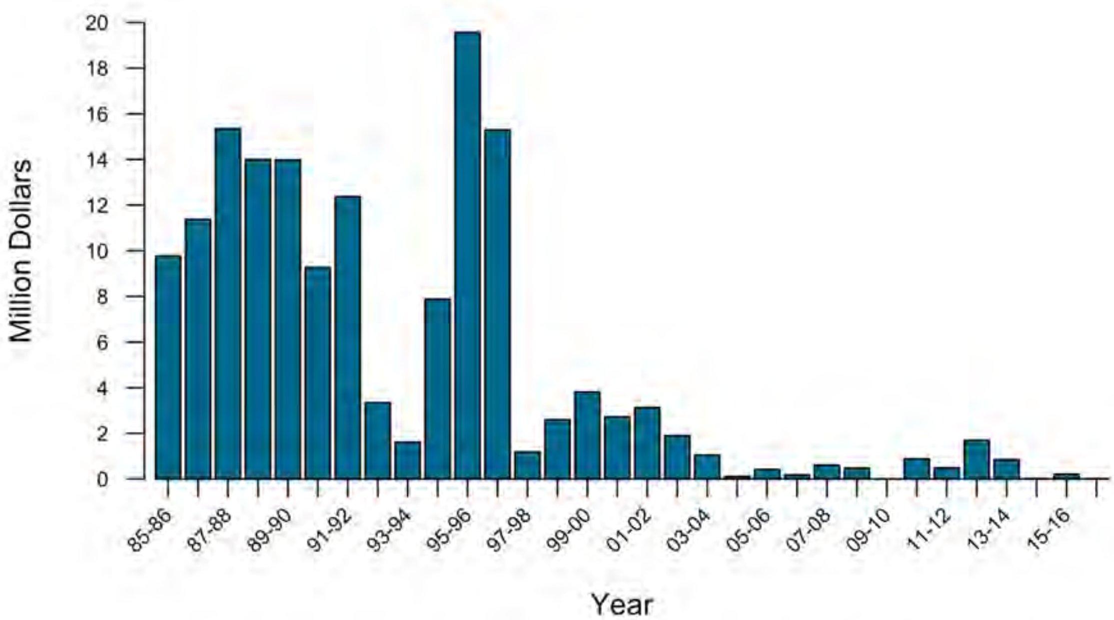

Figure 4-4. Ex-vessel value (in millions of dollars) for the California sac-roe fishery, 1985-2017.

4.7.2 Changes in Participation and Implications for Permitting System

Between the mid-70s and the late 1990s participation in the fishery was high. At the peak, the fishery had over 400 permits, and many more qualified applicants. In 1989, Herring permits became transferrable, meaning that they could be sold to any licensed fisherman. This change had wide ranging implications, and made Herring permits a valuable commodity. Individual Herring permits were valued at approximately $60,000 each in the early 1990s (Spratt, 1992). Herring permits could also be leased to other fishermen, further reducing permit turnover, because permit holders could profit from their permit by allowing someone else to utilize it through a lease arrangement.

With the declines in the price of Herring since the late 1990s there has been a steady reduction in the number of permits fished each year (Figure 4-5). In recent years, the number of permits fished each season has been below 40. In 2014-15 only six permits were fished, due to disagreements between the fleet and buyers in setting the ex-vessel price of Herring. Additionally, permit holders have elected not to renew their permits to avoid paying annual renewal fees, resulting in a decrease in permit renewals. Permit transfers have decreased as well.

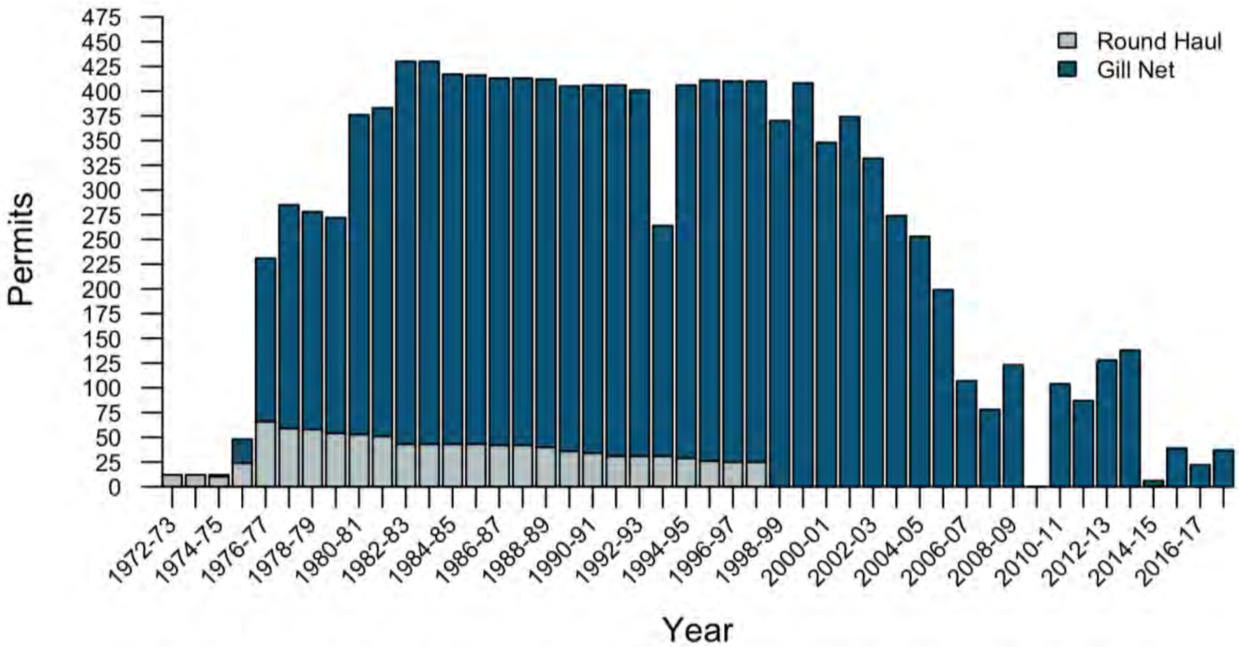

Figure 4-5. Number of permits fished in the sac-roe fishery by gear type each year since the beginning of the fishery in San Francisco Bay.

This FMP establishes a consolidated permit system. Prior to the implementation of this FMP, permit holders were not allowed to own more than one permit within the same platoon, but could own a permit in each of the platoons (December, Odd and Even). Under that system, two permits could have been assigned to a vessel in order to fish two nets. However, each permit had to be owned by a different individual. This led to a system in which permit holders substituted their permits to other fishermen so that vessels could fish a full complement of gear (two nets). Due to the reduction in permit renewals and overall decline in fishery participation, the platoon system is unnecessary, as there is no longer a concern about congestion and conflict on the fishing grounds. Under the consolidated permit system, for permits other than Temporary permits, a permit allows the holder to fish two nets during every week of the season. The Temporary permit allows the holder to fish one net in the San Francisco Bay management area, and up to two Temporary permits may be fished from one fishing vessel. Fishermen are able to own one permit in the Tomales Bay, Humboldt Bay and Crescent City Harbor management areas and fish up to two gill nets of 65 fathoms in length each at the same time from a single vessel with a Tomales Bay Herring permit, or in combination up to 150 fathoms of gillnet with a Humboldt Bay or Crescent City Herring permit. In the San Francisco Bay management area fishermen are able to own up to one Temporary Permit and one San Francisco Bay permit, however a maximum of two nets may be fished from a single fishing vessel. Additionally, a long-term capacity goal of 30 vessels (equivalent to approximately 120 permits under the prior Platoon system) is established for the San Francisco Bay fleet, and no new permits will be issued until the number of renewed permits falls below the long-term capacity goals of 30 San Francisco Bay permits.

In 2014, the San Francisco Herring Association, a group of commercial Herring fishermen, filed a lawsuit against Pacific Gas and Electric (PG&E) for contamination of the San Francisco Bay waterfront. The contamination was the result of PG&E's operation of a manufactured gas plant at Fisherman's Wharf in the late 1800s and early 1900s that turned coal and oil into gas for residential use. The process created large concentrations of chemicals known as poly-aromatic hydrocarbons (PAHs), which have been shown to cause mortality in larval and juvenile Herring. These chemicals are extremely persistent and remain highly toxic for hundreds of years after being released into the environment. PAHs released into the bay have been buried in the sediment, but can be reintroduced to the water column if they are disturbed via dredging or other activities, where Herring may re-encounter these chemicals and be affected by them.

The lawsuit was settled in 2018 (concurrent with the development of this FMP), and the terms of the settlement included a permit buyback agreement in which PG&E agreed to buy at least 40, and up to 80, Herring permits from commercial fishermen. These permits will be permanently retired and cannot be renewed as a condition of the settlement. While this is an external process, it aligns with the Department's permit consolidation goals.

4.7.3 Modern Fleet and Fishing Community Composition

To understand how changes to the permitting system under this FMP affect permit holders and their communities, it is helpful to have information about the composition of the commercial Herring fleet. Ideally, this information would include demographics on permit holders, crews they employ, and the communities where they reside, as well as how they have changed over time. It is also useful to know which other fisheries permittees and crewmembers participate, because changes in regulations in one fishery can affect others. Finally, demographic information about shore-based infrastructure and ancillary employment required to support fishing activity can be useful for understanding socioeconomic impacts to fishing communities. This section presents the state of knowledge concerning the community composition of the commercial Herring fleet at the time this FMP was prepared.

During the 2017-18 season, 138 Herring permits were held for all fishing areas. Of these, four permits were for the Humboldt Bay, five for Tomales Bay, and 129 for San Francisco Bay. Some permittees in the San Francisco Bay fishing area held multiple permits, with nine individuals holding three permits, 14 individuals holding two and 74 individuals holding a single permit. The average age of the permittees at the beginning of the 2017-18 season was 61.5 (Figure 4-6). The majority of permittees as of 2017-18 had participated in the Herring fishery, as crew or as permit holders, for more than 30 years.

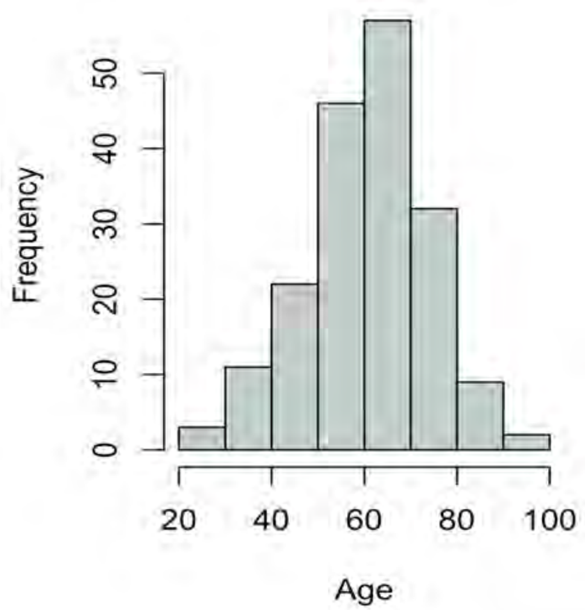

Figure 4-6. Age of permittees in the California sac-roe Herring fishery at the time of FMP development.

Herring permittees primarily live along the West Coast and of those who live in California, the highest percentage of permittees reside in Monterey County (Table 4-1). Most other permittees live in counties adjacent to San Francisco Bay. The remaining permittees live primarily in counties in eastern or northern California, though several permittees reside out of state or in southern California.

Table 4-1. Residence of Herring permit holders.

State	Residents	California Residents - County	Residents
California	78%	Monterey	34%
Washington	19%	Marin	13.5%
Oregon	2%	Sonoma	8.5%
Other	<1%	Mendocino	5.6%
		Contra Costa	5.6%
		Solano	4.2%
		San Mateo	4.2%
		San Francisco	2.8%
		Alameda	2.8%
		Other	18.8%

Four Herring permittees hold general gill net permits, four permittees also hold permits in the deeper nearshore fishery, and three permittees hold drift gill net permits. Three or fewer permittees also hold sea urchin diver permits, non-transferrable lobster permits, and rock crab trap permits. Given the age composition of the fleet, it is likely that Herring permit holders participated in additional fisheries in the past, but have only retained permits that are valuable or transferrable. However, there is limited information regarding permit holders' active participation in other fisheries besides Herring, and there is no information currently available on what federal permits Herring participants hold.

Landings by port area may provide insight into active participation in other fisheries by Herring permits holders. Table 4-2 shows the five largest fisheries by value for the San Francisco, Tomales Bay, Eureka, and Crescent City areas. A number of Herring permit holders that operate out of these ports also participate in the Dungeness Crab and Chinook Salmon fisheries, suggesting that changes in these fisheries might impact effort in the Herring fishery.

Table 4-2. Commercial landings and ex-vessel value for the five most valuable fisheries each in San Francisco, Tomales, Eureka, and Crescent City ports in 2017.

Port	Species	Landings (lbs)	Value
San Francisco Bay	Crab, Dungeness (*Metacarcinus magister)*	2,316,341	$8,560,751
	Halibut, California (*Paralichthys californicus*)	178,512	$1,157,536
	Swordfish (*Xiphias gladius*)	294,383	$1,016,771
	Salmon, Chinook	107,353	$995,818
	Squid, Market (Doryteuthis *opalescens)*	1,217,776	$570,710
Tomales Bay	Crab, Dungeness	1,904	$9,520
	Surfperch, Barred (*Amphistichus argenteus*)	1,206	$2,474
	Surfperch, Shiner (*Cymatogaster aggregate*)	229	$2,290
	Hagfishes (*Eptatretus* spp.)	2,400	$1,800
	Halibut, California	56	$445
Eureka (Humboldt Bay)	Crab, Dungeness	1,432,549	$4,439,861
	Sablefish (*Anoplopoma fimbria*)	683,484	$1,662,447
	Sole, Dover (*Microstomus pacificus*)	2,849,683	$1,257,613
	Sole, Petrale (*Eopsetta jordani*)	740,367	$811,408
	Tuna, Albacore (*Thunnus alalunga*)	143,645	$285,795
Crescent City	Crab, Dungeness	1,466,899	$4,621,571
	Shrimp, Ocean (pink) (*Pandalus jordani*)	2,717,635	$1,262,032
	Sablefish (*Anoplopoma fimbria*)	160,657	$484,217
	Shrimp, Coonstriped (dock) (*Pandalus danae*)	56,131	$279,604
	Rockfish, Black (*Sebastes melanops*)	117,314	$227,112

There is limited information regarding the demographics of crewmembers employed in the Herring fishery, because crewmembers do not need a special permit (only a general California Commercial Fishing License is required). In a survey conducted in 2017 respondents indicated that each permit holder who fishes employs an average of 1.6 crewmembers. There is no information available on how long those crewmembers have been employed or in what other fisheries they may participate.

4.7.4 Market Access

Since the beginning of the roe fishery in California, the primary market for Herring has been overseas. In 1973 sac-roe fisheries developed along the West Coast of North America to supply the demands of the Japanese market. This occurred after domestic Japanese stocks crashed and Japan and the Soviet Union agreed to ban the harvest of sac-roe Herring in the Sea of Okhotsk to prevent continued overfishing of a depleted stock. The Japanese government also liberalized import quotas, which opened the sac-roe market to United States and Canadian exporters.

In recent years, demand for kazunoko in Japan has declined, and roe gift boxes are no longer sold at premium pricing. In addition, reduced demand has led to an oversupply, where unsold roe is carried over to the following year. This has led to very low prices in recent years. The California roe fisheries must compete with those in British Columbia and Southeast Alaska, which have much larger stocks and, consequently, much larger quotas. However, California Herring produce roe that are typically smaller in size than those from British Columbia and Alaska markets, and have a unique golden coloration. This has made the roe product from San Francisco valuable to buyers despite the small size of the fishery, as it allows them to offer a more diverse portfolio of Herring roe products.

Because the primary market for California's Herring is in Japan, it is necessary for fishermen to sell their product to fish receivers who can facilitate processing and export. Herring roe buyers typically process the Herring, but may simply ice and ship whole Herring to a wholesaler. The buyer/processor then sells the Herring roe to a distributer for export to Japanese markets (Figure 4-7). There are currently no local Herring buyers in California, so buyers travel from Washington or British Columbia during the Herring season. Out-of-state buyers typically partner with local fish receivers and off-loading facilities to handle fish coming into each port area. Low quotas and pricing provide little incentive for buyers to travel to San Francisco Bay for the season, and in some years almost no fishing has occurred due to a lack of interest from Herring buyers. At the time this FMP was drafted one to three buyers participated in the annual Herring fishery in San Francisco Bay. As noted earlier, there is no active fishery in the northern management areas.

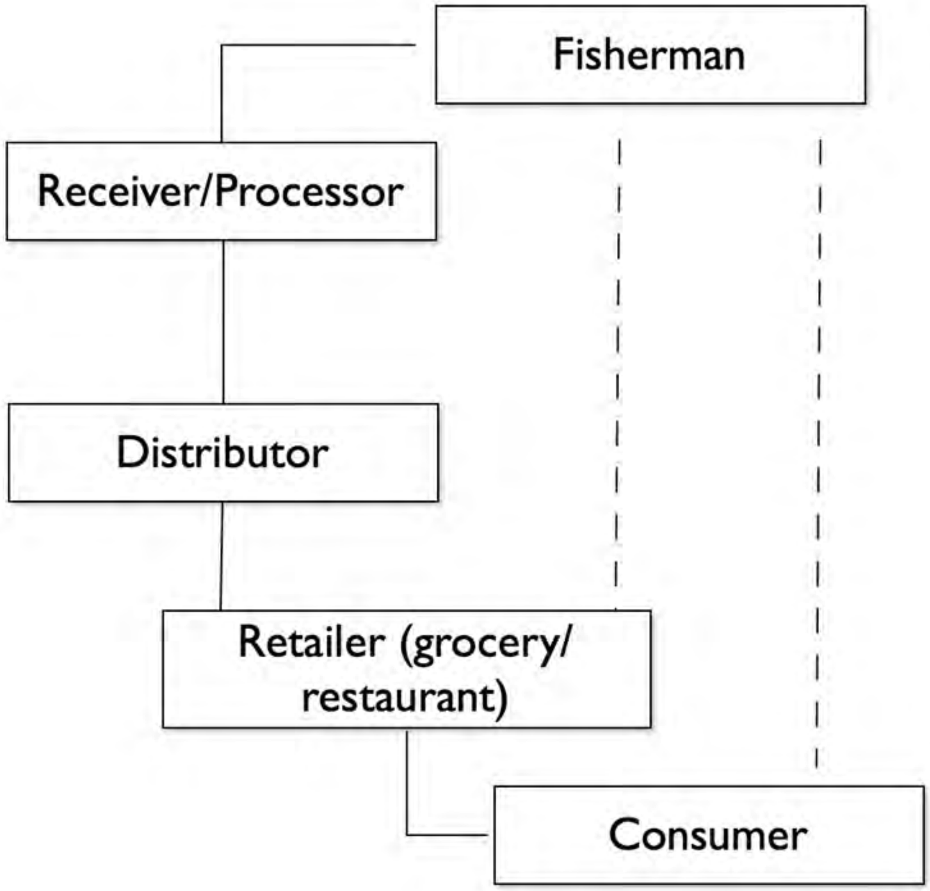

Figure 4-7. Supply chain for commercially-caught Herring caught in California. The black lines show the distribution channels for the Herring roe fishery. The dashed lines show potential channels for a local whole fish market. Note that under this FMP, commercially landed Herring may only be sold to an appropriately permitted buyer (Section 9.1).

Fishermen are typically not contracted to a single buyer. Instead, fishermen consider a number of factors in deciding who to sell their fish, including the agreed price, the reputation of the buyer and the volume each buyer will purchase. Fishermen will also consider who else is fishing for that buyer, and some may choose to avoid a particular buyer to reduce conflict. As additional incentives, buyers may also offer to cover vessel shipping costs (as some Herring fishermen reside in other states) or berthing costs during the fishing season.

While market conditions have depressed Herring fishing along the U.S. West Coast, it is possible that these conditions could change. A change in the amount of roe Herring caught in British Columbia or Alaska, whether due to environmental or management needs, could result in increased demand for California Herring roe, and a subsequent increase in price. Potential markets elsewhere in Asia, particularly in China, could also alter market conditions.

There is also a minor but increasing interest in supplying a local market with fresh, whole Herring for human consumption. A fresh whole fish product could be sold directly to local fish markets or consumers with little processing (Figure 4-7). Proponents believe this could result in higher ex-vessel prices than the roe fishery currently receives. Some stakeholders have expressed concerns that the current Herring regulations present barriers to the development of a local market. However, the available Herring quota can be caught and sold for either roe or fresh fish purposes.

There is currently a requirement that all Herring buyers be in possession of a Herring buyer's permit. This requirement allows the Department to closely monitor Herring landings and avoid quota overages. The fees associated with this permit however could inhibit smaller operators from participating due to cost. Stakeholders have proposed reducing the Herring buyers permit fee to promote local market access. Stakeholders have also petitioned the Commission to allow cast nets to be used in the commercial Herring fishery. Cast nets are able to land smaller quantities of Herring and may produce better quality product than the much larger gill net fishery. It is also possible to alter gill net handling processes to increase the quality of the fish. However, given the fact that Herring are harvested during spawning activity, and are thus of lower overall fat content, there may be an inherent limit to the quality and market value of whole Herring as a human food product (Suer, 1987; Wyatt and others, 1986).

4.7.5 Socioeconomic Considerations for the Northern Management Areas

Much of the focus of regulatory changes to address socioeeconomic needs during development of the FMP has been on the San Francisco Bay area. This is due to the fact that over 90% of participants fish in this management area. Even though there has been no fishing outside of San Francisco Bay since the 2006-07 season, permits are still held for these areas. The primary market obstacles have been low prices, insufficient offloading facilities, and storage and transportation costs. Department staff and shifts in management priorities have also occurred in these areas. As a result, these stocks have gone unmonitored since 2006-07, except for limited data that have been collected for the Humboldt Bay stock. One of the goals of this FMP is to establish a monitoring and management procedure in the event that fishing resumes in the northern management areas (Chapter 7), which could occur if there were a change in product value or market access. Socioeconomic considerations should be part of any proposed changes to management in the northern fishing areas in the future.

4.7.6 Characterizing the Sport Fishery

Another goal of this FMP is to develop regulations to manage the sport Herring fishery, which at the time of development of this FMP had no restrictions on catch or effort. Concerns about a growing level of take by the recreational sector and potential for commercialization made this a priority area to address in this FMP. Sale of any sport-caught fish in California is illegal (FGC §7121). Herring are primarily targeted by sport fishermen when a spawning aggregation moves close to shore to spawn, and must also be in an area that can be accessed by the public. When this occurs, fishing effort is concentrated and intense for a short period. However, very little effort data is available on the recreational sector due to difficulties in intercepting participants. Current recreational fishery surveys employ a random sampling design and do not frequently intercept participants in this fishery (Section 6.1.2.9). A more targeted sampling protocol may be necessary to collect data on the Herring sport fishery and its participants.

Incomplete information has made it challenging to evaluate the likely impacts of potential regulations on the recreational Herring fishery. A better understanding of the socioeconomics of the recreational fishery is needed. Comprehensive information on fishery participants, fishing locations, fishing gear, catch utilization, and primary motivation for fishing is lacking, but this section describes what has been observed about the recreational fishery.

Fishing activity associated with each spawning event generally lasts for 48 hours or less and participants must be able to access a spawning event quickly. Information on the location of spawns is commonly shared using social media and through person to person communication networks. Anglers will typically fish along the shoreline in the intertidal zone, or on piers, docks, and jetties. Recreational anglers are not required to have a sport-fishing license when fishing from public piers in ocean or bay waters. The majority of anglers fish from shore but some use small skiffs to access shallow water areas. Participants primarily use small cast nets (<12 ft) (>3.7 m) in diameter) or hook and line gear known as sabiki rigs, which consist of six hooks attached along the line and are cast from shore. The amount of fish caught per participant ranges widely and based on Department observations, catch can range from a few pounds to thousands of pounds.

Anecdotal information indicates that substantial amounts of Herring caught are used for bait in other fisheries. Herring bait is used for salmon, California Halibut, and Lingcod by recreational anglers. Herring may also be smoked, pickled or canned for personal consumption, or shared with friends and family. Chapter 7 of this FMP addresses management recommendations for the recreational fishery and identifies ways to improve data collection among participants and understanding of the socioeconomics of this sector.

Chapter 5. History of Management

5.1 Evolution of Management System

This chapter describes the evolution of Herring fishery management in California, including the rationale for using a quota-based system, as well as how management measures contribute to the sustainability and orderly conduct of this fishery. Since the beginning of the Herring sac-roe fishery, the primary basis for ensuring the sustainable use of the resource has been annual quotas that are set to achieve harvest rates that are appropriate to the size of the stock. When the sac-roe fishery first opened, the stock size in each management area was unknown. Herring are highly dynamic, and their stock size can fluctuate widely from year to year. As a result, annual monitoring programs were developed to estimate the total SSB during each spawning season (November – March) in San Francisco and Tomales Bays, and these estimates were used to set the following year's quota.

These monitoring programs and annual quota-setting procedures allowed the Department to adaptively manage the Herring fishery based on stock health indicators. Concerns about stock health in the 1990s led to a reduction in harvest rates, and since 2000 quotas have been set to target harvest rates of approximately 10% or lower. One of the goals of this FMP is to develop a plan that formalizes and builds upon this precautionary management approach employed since 2000.

The sac-roe sector of the California commercial Herring fishery was tightly regulated from its inception, and many of the management procedures that would shape the fishery for decades were developed in the early years of the fishery. Due to the initial high value of sac-roe, high participation levels, as well as congestion and conflict in the San Francisco fishing area, the Herring fishery has benefitted from an intensive level of management. Herring regulations changed yearly as the fishery expanded, and many regulations were designed to address socioeconomic rather than biological issues. As a result, the Herring fishery served as a testing ground for many new management concepts in California, including a limited entry system, permits issued by lottery, individual vessel quotas, quota allocation by gear, the platoon system used to divide gill net vessels into groups, the transferability of fishery permits, and the conversion of permits between gear types (California Department of Fish and Game, 2001). Many of these management tools were controversial, but were necessary to address socioeconomic conflicts in a congested fishery.

The MLMA directs FMPs to outline the types of management measures they employ to promote a sustainable and productive fishery. This Chapter describes these measures, as well as the rationale behind them.

5.2 Catch Limits

5.2.1 Limits on Catch

Since the beginning of the sac-roe fishery, annual quotas (catch limits) have been the primary management tool for ensuring stock sustainability. Fish that form spawning aggregations are potentially vulnerable to overfishing, and a single unit of effort can produce very high catch rates. In addition, CPUE may remain high even when stock abundance declines. For this reason, quotas are a reliable way to achieve desired harvest rates and maintain fishery sustainability.

5.2.2 Target Harvest Rates

Quotas are often set to achieve a desired harvest, or exploitation, rate. The Pacific Fishery Management Council (PFMC) recommended that the maximum harvest rate of Herring not exceed 20% of the available biomass (Pacific Fisheries Management Council, 1982). Quotas in California were set to achieve a harvest rate of 15% for the first two decades in this fishery (Figure 5-1). This was viewed as a precautionary approach because, given that a previous season's estimated stock size was used to set the subsequent season's quota, a 15% intended harvest rate provided a buffer in the event fewer spawning Herring than expected returned in the following year. However, after a variety of indicators suggested declines in stock health, including decreased spawning abundances, reduced number of older individuals in the stock, and increased variability in year-to-year abundance, a 15% target harvest rate may not have provided adequate protection for California's Herring stocks.

While fishing likely contributed to declines observed earlier in the fishery, changing environmental conditions and alterations to spawning and rearing habitat may have reduced the productivity of the Herring stock in recent years. Additionally, Herring are at the southern end of their range in the central CCE, and target harvest rates applied to northern stocks may not be appropriate for use in California. A review of the Department's management protocol in the early 2000s recommended that target harvest rates between 10-15% should be applied (Appendix C). Since then quotas have been set to achieve harvest rates of 5-10%, depending on stock status and environmental conditions (Figure 5-1). In Tomales Bay, the quota-setting policy changed to a 10% target harvest rate in the mid-90s after the fishery was closed due to low abundances (Appendix H).

Herring fisheries outside of California still set quotas at 20% of the estimated spawning biomass. However, these fisheries typically use in-season survey methods to determine whether a certain level of spawning has occurred (spawn escapement) prior to the quota being taken, which results in a quota that more accurately implements the intended harvest rate. In California, it is not possible to set in-season harvest levels due to survey methods used and staffing constraints. Rather, quotas are set based on the previous year's SSB estimate, which comprises the estimated weight of all spawning Herring plus commercial catch for that year. Due to natural fluctuations in the size of Herring stocks, the actual exploitation rate (i.e. tons of Herring landed as a proportion of SSB that season) may be higher or lower than the intended (target) harvest rate (i.e. a given season's quota as a proportion of the prior season's SSB). When this management approach was first developed in the 1970s and 1980s, Herring stocks in San Francisco Bay exhibited more stability from year-to-year than they have since 1990 (Sydeman and others, 2018). As the variability in the stock increased through the 1990s and 2000s, the probability of exploitation rates exceeding target harvest rates has also increased. Conservative target harvest rates (i.e. in the 5-10% range) have helped buffer against this type of management uncertainty.

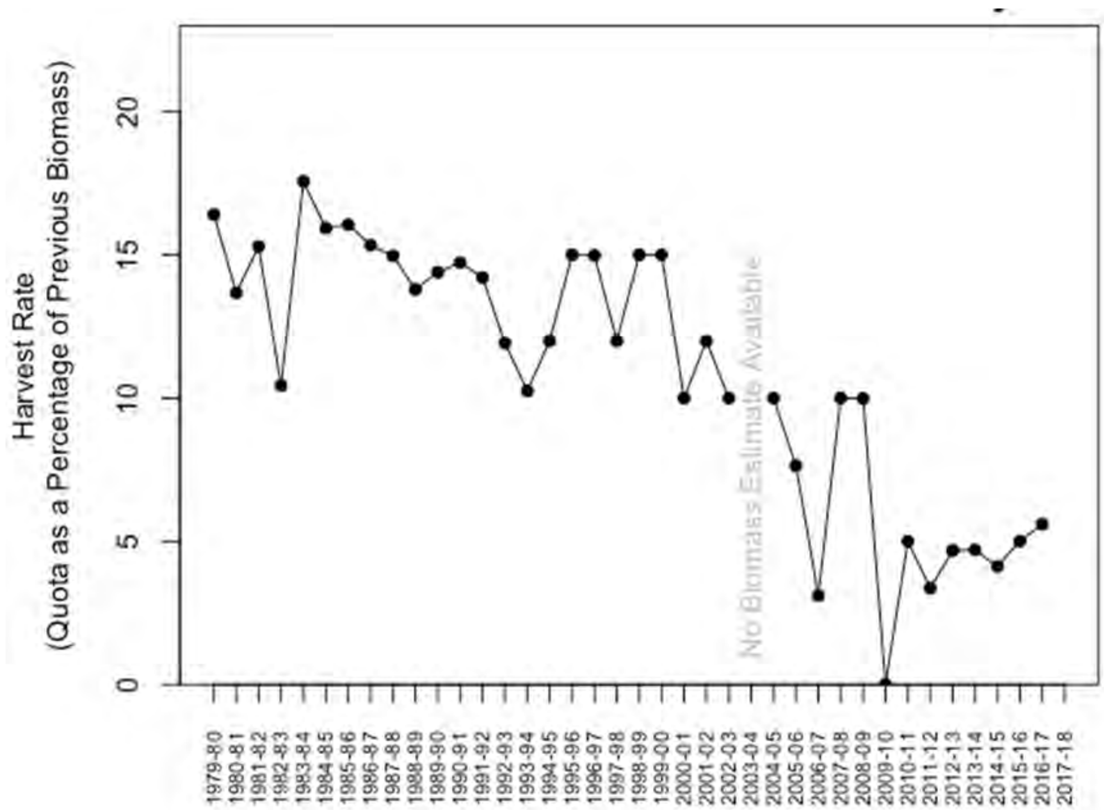

Figure 5-1. Intended harvest rates for the San Francisco Bay Herring fishery.

5.2.3 Requirements for a Quota-Based Harvest Rate Approach

Achieving a sustainable harvest rate requires the ability to estimate the size of the stock. Survey methodologies are employed annually to provide an estimate of the size of SSB in each year. This is possible because Herring spawn in a relatively well-defined area in specific habitats in California. However, stock declines in San Francisco Bay may have been masked because two separate survey methods (spawn deposition and hydro-acoustic) used during the late 1980s and 1990s produced differing spawn abundance estimates (Section 6.1.2.3). A 2003 external review recommended the Department manage based on the more conservative metric of observed spawn deposition (Appendix I), and in light of this recommendation, a retrospective analysis suggests that harvest rates may have been higher than intended, and in some years surpassing 20% of the spawning stock.

Quota-based management also requires an ability to track catch in near real time, as well as the ability to stop fishing quickly when the quota is reached. This is difficult in many California fisheries because landings are reported on paper landing receipts, and there is often a lag of several weeks before this information is mailed and manually entered into the Department's landings database. To overcome this issue, Herring roe buyers are required to obtain a special permit, which has allowed Department staff to monitor offloading and has facilitated communication between Department staff and Herring processors to manage quotas. However, in some years quotas were exceeded in Humboldt Bay and Crescent City Harbor, suggesting that catch monitoring was more difficult in those areas.

5.2.3.1 Allocation of Quota between Sectors

Allocation of the quota between sectors of the fishery evolved as the fishery expanded in the early years. By the 1980s an allocation policy was in place, and fishery quotas were split (67/33%) between the gill net and round haul gears (Spratt, 1992). Quotas were further allocated to each fleet (Odd/Even platoons, and December gill net fleets, and purse seine and lampara fleets) based on the number of participants. In San Francisco Bay a vessel quota was established for round haul gear beginning in 1981-82, which helped to reduce competition as well as dockside congestion (Spratt, 1992). Round haul gear was ultimately phased out in 1998 and the quota was reassigned to the gill net fleet. The whole ('fresh') fish fishery was also allocated a 20-ton quota (18 metric tons) each year until 2013, when it was combined with the sac-roe quota to provide better access for the local whole fish market for Herring.

When the San Francisco Bay HEOK fishery began, quotas were initially allocated for each participant by calculating each permittee's share of the total sac-roe sector quota based on whether they had converted a round haul or gill net permit to the HEOK sector. A conversion factor based on fecundity and sex ratios (Moore and Reilly, 1989) (Section 4.3.1) was used to determine the total product weight of eggs on kelp that could be landed. Prior to implementation of this FMP, each HEOK permittee was allocated an egg-on-kelp 'equivalent' of 1% of the total roe fishery quota (up to 10% with the maximum of ten participants fishing) (Section 7.8.1.1, Appendix N).

In Tomales Bay individual quotas were implemented in 1975-76, with a larger allocation going to round haul permits due to their greater operating costs (Spratt, 1992). Individual quotas were eliminated the following year in favor of group gear quotas. According to Spratt (1992), permittees favored a single sector quota, preferring the possibility of larger individual catches. Gear-based allocation was eliminated in the mid-80s when round haul gear was prohibited in Tomales Bay. Quotas in Humboldt Bay and Crescent City Harbor have always been a general quota and not assigned by gear or allocated to an individual permittee or vessel.

5.2.3.2 Determining When the Stock is Overfished and Initiating Rebuilding

The Herring fishery has been intensively managed for many years, and over time the policy for setting quotas evolved. Quota setting policy prior to FMP implementation did not include the use of a true HCR, which is a predetermined method for determining when management changes are warranted. An HCR specifies the stock conditions that would indicate that the stock is overfished or below its limit threshold, and what actions should be taken to rebuild the stock. They also dictate the magnitude of management response required to meet stock objectives.

While prior management policy for Herring had many desirable aspects, when and how to reduce quotas below a 10% harvest rate each year was based on ad hoc recommendations from Department staff. In addition, there were no defined limits for determining when the stock was overfished or otherwise in a depressed state, or if overfishing was occurring. Fishery closure guidelines were not clearly defined, and there was no established rebuilding plan should the population be in a depressed state. The formal HCR-based management policy established by this FMP improves managers' ability to promote the sustainability of California's largest Herring fishery in San Francisco Bay.

5.2.4 Limits on Incidental Catch in Other Fisheries

Herring were commonly taken in fisheries targeting other coastal pelagic species up until 2010. The primary gear type utilized was purse seine, and the majority of these landings occurred in the summer months in the Monterey area, though a small number of landings were reported further south. The ocean waters fishery was closed in 2010 due to concerns about low abundances in the San Francisco Bay stock. Regulations now specify that Herring may only be taken as an incidental species, provided the landed catch is no more than 10% Herring by weight.

5.3 Effort Restrictions

While a quota has been the primary mechanism for limiting fishing mortality, the sac-roe fishery in San Francisco Bay has been managed through a limited entry system since its early years. Limiting effort through a permitting system has had a number of benefits. First, each of the fishing areas has limited space and a number of other concurrent uses, and restricted access has reduced crowding and user conflicts. The restricted access system has also provided an incentive for regulatory compliance because violators could have a permit suspended or revoked. Finally, the restricted access program has provided an incentive for industry stewardship and involvement in the management process, because permit holders were assured continued access to the resource in future years.

5.3.1 Permits in San Francisco Bay

During its first year, the sac-roe fishery in San Francisco Bay was open to all interested participants, but in the following years the number of permits was capped, and a lottery was held when the number of applicants exceeded the number of permits available. When quotas began to increase, it was decided to increase the number of permits as well because demand for a Herring permit was high and there was a desire not to create a windfall for existing permit holders (Spratt, 1992). Qualification criteria and a points system based on fishery participation were established, and the number of permits slowly expanded over a period of ten years until the fishery was deemed to be at maximum capacity in the early 1980s, when permit caps were established. After that the number of participants remained steady for the next two decades (Figure 4-5, Appendix J).

The permit system evolved over time to meet the needs of the fleet and to address regulatory issues as the fishery evolved. The following sections describe some of the major changes to the permitting system that have shaped the current fishery. Permit consolidation under this FMP, including the elimination of the platoon system, is discussed in Sections 4.7.2 and 7.8.2.

5.3.1.1 Development of a Platoon System

High prices for sac-roe caused rapid expansion of the fishery, and by the late 1970s, the fishing grounds in San Francisco Bay became congested. In the 1978-79 season the Commission divided the 220 gill net permit holders by permit number into two groups, known as the “Odd” and “Even” platoons. Each platoon was allocated a part of the quota and allowed to fish during alternating weeks of the season. To further address concerns about congestion in the face of high demand for Herring permits, the Commission issued permits for a three-week gill net fishery in December. Prior to this, commercial Herring fishing in San Francisco Bay had only been allowed January through March.

Prior to FMP implementation, regulations allowed an individual to own a permit for each of the three gill net platoons (December, Odd, and Even) in San Francisco Bay. Permittees could not hold more than one permit in each platoon and not more than three permits in total. This restriction prevented individuals from consolidating a large number of permits and maintained access to the sac-roe sector for as many participants as possible. Due to lower stock abundance in December, that fishery was closed in 2011, and all December permits were assigned to either the Even or Odd platoon.

5.3.1.2 Transferability

In 1989, the Legislature made Herring permits transferrable, meaning that they could be transferred to any licensed fisherman. Prior to this, Herring permits could only be transferred to partners, heirs, or siblings. This drastically changed the system by which permits were acquired, and no further lotteries for new permits were held. This also made it much more difficult for the Department to meet permit caps through attrition alone.

5.3.1.3 Vessel Reduction

In 1993-94 the San Francisco gill net permit regulatory structure was changed such that two permits could be fished on the same vessel simultaneously, often by substituting one's permit to another permit holder. This effectively reduced the number of vessels in the fleet without reducing the number of nets fished. Prior to this change, only one gill net could be fished on each vessel.

5.3.1.4 Elimination of Round Haul Permits

In 1994, the Commission adopted regulations stating that all round haul permittees had five years to convert their permit to a gill net permit. Those who converted voluntarily were issued a CH permit, equivalent to two gill net permits, to incentivize conversion. In 1998 all remaining round haul permits were converted to gill net permits.

5.3.2 Permits in Tomales Bay, Humboldt Bay, and Crescent City Harbor

A limited entry system was established for Tomales Bay in 1975-75. In 1978-79, Tomales Bay and Bodega Bay were combined into a single permit area with a cap of 69 permits. Tomales permittees were split into two platoons to alleviate congestion and conflict on the fishing grounds. Between 1981 and 1983, Tomales permittees were allowed to exchange their permits for available San Francisco Bay permits, reducing the number of permits in Tomales to 41. Subsequently, a cap of 35 permits was established for Tomales Bay.

Few permits have been issued in the northern management areas. In Humboldt Bay, six permits were initially issued, but in 1977 the number was reduced to four. In 1977 four permits were issued for Crescent City Harbor. Since the 1983-84 season only three permits have been renewed annually. At the time this FMP was drafted, no changes had been made to the regulations governing Herring fishing in the Humboldt and Crescent City Harbor permit areas since 1983. These areas did not have the same levels of participation that resulted in the competition and conflict experienced in the southern permit areas.

5.4 Gear Restrictions

Prior to FMP implementation, each gill net permit in San Francisco Bay allowed the holder to fish a single net (65 fathoms (ftms) in length) in the platoon to which it was assigned. Each vessel could fish up to two nets, and two permit holders could fish their gear from the same vessel simultaneously. This section discusses changes in gear restrictions leading to the modern fishery.

5.4.1 Transition from Round Haul to Gill net

When the Herring sac-roe fishery first began, there were no restrictions on gear type specific to this fishery. However, when set (anchored) gill nets were legalized by the Department in 1976-77 they became the preferred gear type. By the late 1970s the impacts of each gear type on the stock had become more apparent. Catch sampling revealed that round haul gear primarily caught 2 and 3 yr old Herring, while the gill net catch was dominated by 5 and 6 yr olds. Gill nets consistently caught larger Herring and a higher percentage of females, leading to higher roe percentages (Spratt, 1981). The Commission determined that no new round haul permits would be issued for the San Francisco Bay fishing area. During the 1980s the number of round haul permits declined due to attrition (Figure 4-5, Appendix J). However, in 1989 permits became transferable, which eliminated the mechanism for decreasing the number of round haul permits and stabilized the round haul fleet at 42 permits.

In the early 1990s there was concern about declining age structure of the San Francisco Bay stock, particularly the decrease in age five and older Herring that had once dominated commercial catches. In addition, there were concerns about mortality associated with test sets by seiners (round haul permittees), testing roe content and releasing the Herring if the roe percentage was not desirable. Following the 1994 Department recommendation, the Commission adopted regulations to convert the fishery to an all gill net fleet (Appendix K).

5.4.2 Reduction in Gear Fished per Permit

In the 1993-94 season the amount of gear that could be fished by an individual gill net permit was reduced from 130 ftms of net (2 shackles) to 65 ftms (1 shackle). This effectively reduced each permit to a single net and reduced the amount of gear being used by half.

5.4.3 Changes in Gill net Mesh Size

Regulations specify the total length in fathoms (ftms) and height (depth of net in number of meshes) of each net in order to limit the efficiency of the fleet and reduce the potential for spatial conflicts between fishermen. There are also restrictions on the minimum and maximum allowable mesh size, which determines the selectivity of the gear (i.e., the size and age of fish it will catch). Nets with larger mesh size catch larger fish and more females, suggesting that larger mesh sizes are beneficial to the fishery both economically (by increasing roe percentages) and biologically (by focusing take on larger and older fish) (Reilly and Moore, 1987). The minimum mesh size in the San Francisco Bay permit area has varied over time, while maximum mesh size has remained unchanged (Table 5-1, Appendix L). After the 1997-98 El Niño, a decline in the size and condition of Herring was observed, and the fishing industry proposed a reduction in mesh size to 2-in (50 mm) to improve catch rates. The fishing industry expressed concern that the use of 2.125-in (54 mm) mesh in San Francisco was harmful to the resource because fish were squeezing through the gill nets, and in turned harmed or killed in the process. Department staff expressed concern that 2-in (50 mm) minimum mesh size would increase the catch of 2 and 3 yr old Herring, which conflicted with management objectives of targeting older age classes. Despite these concerns, the Commission reduced the mesh size in 2005 to 2-in (50 mm). Since that time, the proportion of age four and older fish caught in the fishery has increased (Figure 5-2), likely due to several years of low harvest rates increasing the number of older fish available in the stock. By 2014-15, the proportion of age three fish had returned to a level similar to that observed in the early- and mid-90s, and in 2016-17 a measurable proportion of 7 yr old Herring were taken for the first time in 20 years. Poor recruitment is likely cause for the drastic reduction in the proportion of 3 yr old fish observed in 2017-18.

Table 5-1. Summary of mesh size requirements for the San Francisco Bay gill net fleet.

Period	Gill net Mesh Size (in)	
	Minimum	Maximum
1976 to January 14, 1983 (No restrictions prior to 1976)	2	2.5
November 28, 1982 – December 16, 1983	2.25	2.5
January 2, 1984 – March 11, 2005	2.125	2.5
December 19, 2005 – Present	2	2.5

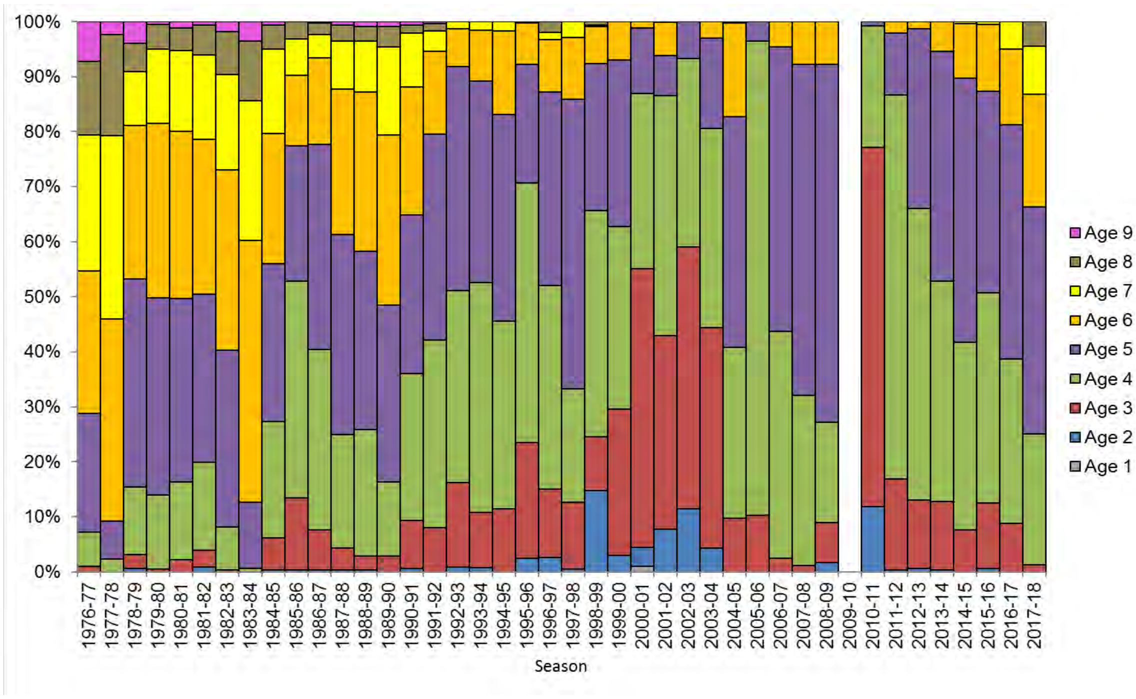

Figure 5-2. Age structure of the commercial Herring catch between the 1976-77 and 2017-18 seasons (the fishery was closed in 2009-10).

5.5 Spatial Restrictions

Commercial fishing for Herring is confined to four management areas in California: San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor. Commercial Herring fishing is prohibited in all other areas, including ocean waters governed by the state, though Herring may be landed as incidental catch provided they are no more than 10% of total landings.

There are numerous fishing area closures across San Francisco Bay (Figure 5-3). Spratt (1992) provides a comprehensive description of how spatial restrictions evolved in San Francisco Bay in the early years of the fishery. Most were instituted due to conflicts between Herring fishing gear and other on-the-water activities that occur in a highly populated urban area. There are closures that protect Herring spawning areas near Sausalito, as well as restrictions on fishing in the deep-water holding areas in the South Bay to protect Herring prior to spawning. Richardson Bay is considered a conservation area and has never been open to commercial gill net Herring fishing activity. Since subtidal spawn deposition surveys began, a majority of observed spawns have occurred in Richardson Bay. This closure therefore protects Herring during spawning in one of the most important spawning areas in San Francisco Bay. HEOK fishing is allowed in specified areas provided rafts and cork lines are affixed to permanent structures to prevent impacts associated to anchoring in eelgrass beds. This regulation also helps Department staff to locate and monitor HEOK fishing activity.

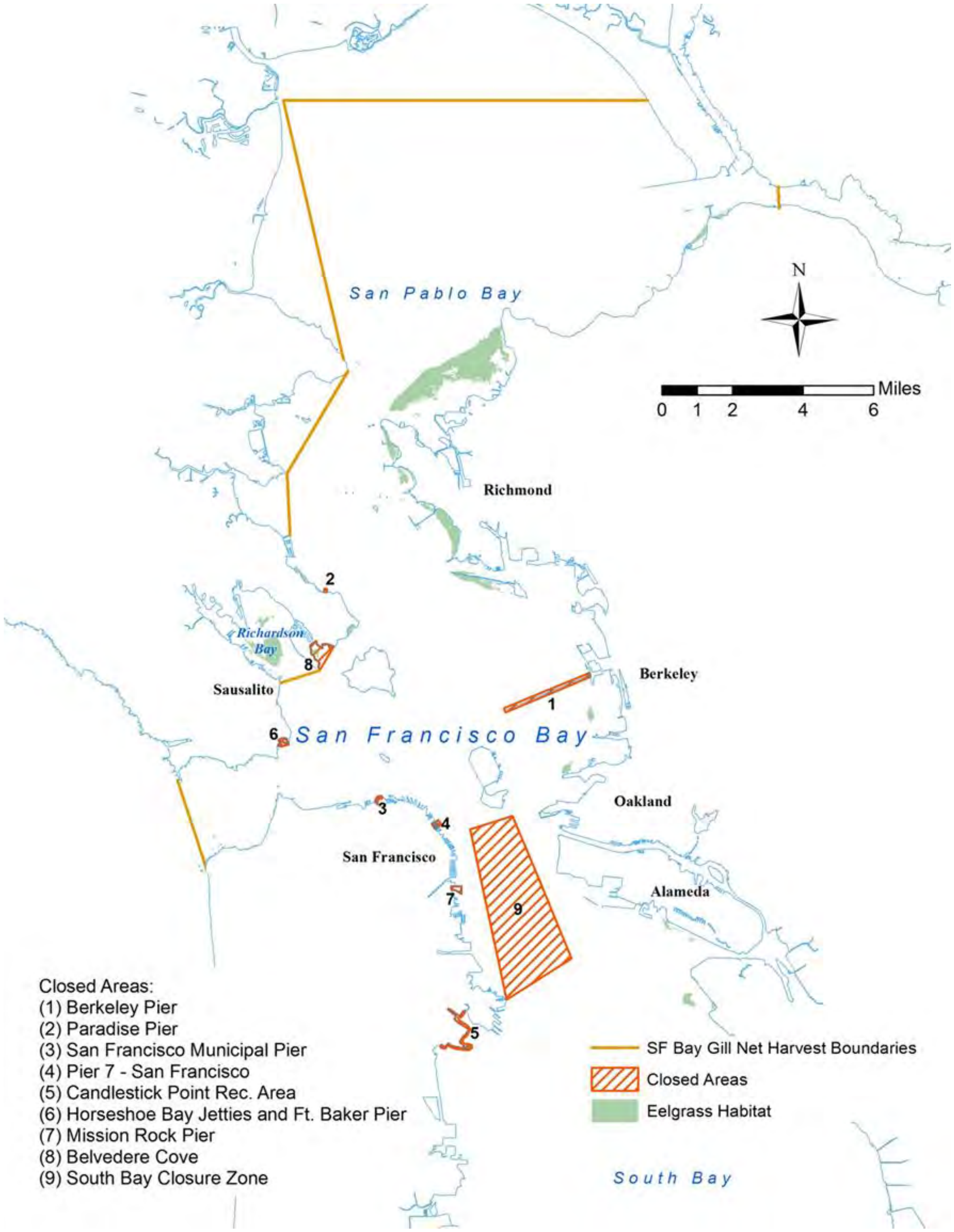

Figure 5-3. Spatial restrictions on Herring fishing in San Francisco Bay. Eelgrass habitat from Merkel and Associates (2014).

5.6 Temporal and Seasonal Restrictions

5.6.1 Herring Fishing Seasons

The Department regulates commercial Herring fishing in California via seasonal closures. The Herring sac-roe fishery is limited to the winter months when Herring come into bays, estuaries, and coastal areas to spawn (December-March in California) and additional weekend closures are used to protect the Herring stock and minimize user conflict in San Francisco Bay (Table 5-2). The Herring roe fishery begins January 1 and extends to March 15, though in practice the quota is usually taken by mid to late February.

Between 1980-81 and 2008-09 there was a three-week fishery in December for those who held December permits. This fishery had a separate quota from the regular season. If the full December quota was not taken during the month of December, these permits could be fished again after the regular season Herring Odd/Even quotas were reached. This fishery was eliminated after very low biomass was observed in 2008-09 to protect the older age classes of fish that tend to spawn earlier in the season and were often targeted by the December fishery.

Herring spawning typically occurs later in Humboldt Bay and Crescent City Harbor, which is reflected in the opening and closing dates for these areas (Table 5-2). HEOK can be fished in San Francisco Bay any time between December 1 and March 31.

Table 5-2. California Herring fishery season dates prior to the implementation of this FMP.

Sector	Start	End	Notes
San Francisco Bay	1-Jan	15-Mar	Starts at 1700 on January 1, may delay to first Sunday if January 1 falls on Friday or Saturday. Closes at 1200 each Friday until Sunday at 1700 weekly.
Tomales Bay	26-Dec	22-Feb	
Humboldt Bay	2-Jan	9-Mar	
Crescent City Harbor	14-Jan	23-Mar	
HEOK	1-Dec	31-Mar	
Whole ('Fresh') Fish	1-Jan	15-Mar	Incorporated into sac-roe fishery beginning in the 2013-14 season. Previous dates were November 2 - March 31.
December Fishery (San Francisco Bay)	1-Dec	3 weeks later	Inoperative as of 2010
Open Ocean - North	1-Apr	30-Nov	Inoperative as of 2010
Open Ocean - South	1-Apr	31-Oct	Inoperative as of 2010

Prior to the 2013-14 season the commercial take of Herring for the whole ('fresh') fish market was open between November 1 and March 31, but restricted during the roe fishery to prevent Herring taken under fresh fish regulations from entering the roe market (Spratt, 1992). In 2013, regulations were changed to eliminate distinctions between whole fish and sac roe fishery sectors, effectively allowing Herring to be landed for either purpose, at any time during the roe fishery, without a market order. The ocean waters fishery was also regulated by a season before it was closed in 2010 to protect Herring stocks (Table 5-2).

5.6.2 Temporal Restrictions

5.6.2.1 Weekend Closure

In San Francisco Bay, weekend restrictions are in place for the commercial Herring fishery to prevent conflicts between user groups, primarily recreational boaters that frequent the bay beginning on Friday. A weekend closure occurs at 1200 each Friday to Sunday at 1700 each week through the season. Tomales Bay, Humboldt Bay and the Crescent City Harbor commercial Herring fisheries are permitted to fish seven days per week.

5.6.2.2 Nighttime Restrictions on Unloading

In San Francisco Bay, Herring fishermen are only allowed to unload between 0600 and 2200. This restriction was put in place to reduce the noise associated with Herring offloading pumps near residential areas such as those in Sausalito, it also benefits Department staff for enforcement and quota monitoring. No similar nighttime restrictions exist for the other fishing areas.

5.7 Limits on Size or Sex

There are no direct limits on the size of Herring that are retained in either the sac-roe or whole fish sectors. However, the restrictions on mesh size ensure that the gill nets select larger, older fish.

There are no limits on which sex of fish can be retained in the Herring fishery. The sac-roe fishery sector targets mature, ripe females because the product of this fishery are the egg skeins. Spawning Herring are part of large, mixed-sex spawning aggregations so there is no method to effectively target only female fish. As a result, both females and males are landed in this fishery. However, fishing later in a given spawning aggregation results in catch of a higher proportion of females, because the males initiate spawning by releasing milt prior to females depositing their eggs.

5.8 Management of the Recreational Sector

The recreational fishing of Herring was long thought to contribute a small percentage to the total Herring removals each year, and prior to the development of this FMP there were no restrictions on catch or fishing effort.

Recreational participants are not required to have a fishing license if fishing from a public pier or jetty. However, recent concerns about increasing catch levels and the possible commercial sale of recreationally caught Herring have prompted the Department to propose regulations to better manage the recreational sector (Chapter 7).

5.9 Management Measures to Prevent Bycatch

A number of restrictions have been put in place to reduce the impact of bycatch during Herring fishing activities. These include limits on the species that can be retained and gear restrictions designed to minimize interactions with other species. In addition, there are restrictions on Herring discards.

5.9.1 Amount and Type of Bycatch

No data exist on the relative rates of incidental take of other fish species in Herring gill nets, but a number of species are accidentally taken during commercial Herring fishing operations (California Department of Fish and Game, 1998). The species most likely to be taken are relatively small in size and more vulnerable to the mesh size used in Herring gill nets. Species observed in gill nets include: Jacksmelt, *Atherinopsis californiensis*; Pacific Sardine; Surfperch; Soupfin Shark, *Galeorhinus zyopterus*; American Shad*;* White Croaker, *Genyonemus lineatus*; and unidentified crab (California Department of Fish and Game, 1998).

Department staff observed the incidental catch in the research gill nets used to survey the fishery during three different years in San Francisco Bay and found the bycatch rate to be less than 0.5% (Table 5-3). The species taken included: Brown Smoothhound, *M. henlei;* Spiny Dogfish*;* English Sole, *Parophrys vetulus;* Pacific Sanddab, *Citharichthys sordidus;* Staghorn Sculpin, *Leptocottus armatus;* silverside smelt, family Atherinopsidae; Shiner Perch, *Cymatogaster aggregata;* and Jack Mackerel. While the research gill nets use a variety of mesh sizes and are not identical to commercial gill nets, they provide some indication of the relative rate of the incidental take of other fish species during the Herring season.

Table 5-3. Proportion of total take of incidentally caught fish in Herring research gill nets (California Department of Fish and Game, 1998).

Season	Hours Fished	Herring caught (Numbers)	Incidental Catch (Numbers)	Incidental Catch Rate
1982-82	154	4393	7	0.0016
1983-84	78.6	1636	8	0.0049
1988-89	18.3	440	1	0.0023

Bycatch rates are low due to a number of different management restrictions. Herring vessel operators are required to be no more than three nautical mi from their nets while fishing the waters of San Francisco Bay. Due to operational needs of the fishery Herring nets are typically not left unattended for long periods of time. As a result, should a seabird or marine mammal become entangled they are likely to be freed quickly, reducing the chance of mortality.

5.9.2 Interactions with Sensitive Species

All fish caught in Herring gill nets must be retained except for the following species: sturgeon; California Halibut; salmon; Steelhead, *O. mykiss;* and Striped Bass, *Morone saxatilis*. If caught these species must be returned to the water immediately (CCR Title 14 §163 (e)(6)). Given the size of Herring gill net mesh, larger fish such as sturgeon are unlikely to be gilled. Combined with the shallow depths at which fishing occurs, mortality of large released fish is thought to be low (Spratt, 1992).

Small fish, however, are more vulnerable to the fishing gear. The primary ecological concern is the effect of the Herring gill net fishery on young salmonids in San Francisco Bay, with both listed species of salmon and Steelhead present. These include the Sacramento River winter-run Chinook Salmon, which is listed as endangered under both the California Endangered Species Act (CESA) and the Federal Endangered Species Act (ESA). Central Valley spring-run Chinook Salmon, Central Coast California Steelhead, and the Central Valley Steelhead are listed as threatened under both CESA and ESA.

Although Sacramento River winter-run and Central Valley spring-run Chinook Salmon smolts occur in Central San Francisco Bay during the Herring fishing season, the peak timing of smolt emigration typically occurs in March and April, after the Herring fishing season has ended, though the timing of these peaks can vary and smolt emigration can overlap temporally with the commercial Herring fishery. Despite any temporal overlap, most smolts remain in the main channels and move through the bay relatively quickly and are therefore not likely to occur in the nearshore areas where gill nets are often set. The Department's Bay Study Program has sampled Chinook Salmon smolts during the Herring fishing season since 1981, and the majority of fish sampled are much smaller than 165-170 mm (6-7 in), the point at which fish become vulnerable to the Herring gill nets (California Department of Fish and Game, 2005). As a result, the Herring fishery in San Francisco Bay is unlikely to pose a threat to Chinook Salmon.

Steelhead from both the Central Coast California and Central Valley Evolutionarily Significant Units (ESU) occur in San Francisco Bay during the Herring fishing season. Most Central Valley and Central Coast Steelhead emigrate after two years in freshwater, with peak emigration between January and May (McEwan, 2001; Rabin and Barnhart, 1986). The Department's Bay Study Program surveys collected Steelhead ranging from 112-277 mm (4-11 in) FL (mean=213 mm (8 in) FL, n=36) during the Herring fishing season. Because of their size, emigrating Steelhead could be captured or injured by the Herring gill nets. While there are no data indicating that Steelhead are caught by the Herring fishery, these fish are the most vulnerable salmonid species due to their life history while in the bay, particularly near the mouth of Steelhead-producing streams in the South Bay and Central Bay near Corte Madera Creek.

5.9.3 Historical Restrictions on Round Haul Gear to Prevent Bycatch

Bycatch rates for round haul gear are generally much higher than gill net. Historically, most of San Francisco Bay has been closed to encircling nets (including purse seine, lampara, and beach nets) in order to prevent the take of salmon, Striped Bass, sturgeon, and American Shad. Round haul gear is currently prohibited, but when round haul vessels were allowed in the Herring fishery, they were required to place rigid metal grate with parallel bars no more than 3 inches apart over the hatch when loading fish into the hold to prevent the bycatch of sport fish. Any large fish would be deflected onto the deck where they could be returned to the water. There are no data on the post release survival of these fish, though Spratt (1992) reports that they were returned to the water "unharmed".

5.9.4 Discards and Herring as Bycatch

5.9.4.1 Discards

Currently, all fish caught in Herring gill net other than the prohibited species listed above must be retained, including all Herring landed in excess of quotas. This helps Department staff monitor all removals from the spawning stock.

A vessel quota was established for round haul gear beginning in the 1981-82 season to reduce competition with the gill net fleet as well as dockside congestion (Spratt, 1992). However, this vessel quota led to the practice of seiners setting on Herring, testing roe content and releasing the school of Herring if the roe content was not desirable (Spratt, 1992). The degree of injury caused by this practice is not known, but Department staff were concerned that multiple boats testing the roe content would increase mortality of Herring. In the 1991-92 season the Department instituted a test boat program to sample roe content. If the roe content was adequate the fishery would open for the day and all sets made had to be retained and landed (Spratt, 1992). The need for a test boat program was eliminated with the conversion of the round haul fleet to gill net permits.

5.9.4.2 Herring as Bycatch

In ocean waters, an incidental allowance of no more than 10% Herring by weight of any load composed primarily of other coastal pelagic fish species or Market Squid may be landed. If more Herring than this is caught it must be released.

5.9.5 Ghost Fishing

Gill nets may be lost in the course of Herring fishing activities. If these nets are not recovered, there is a potential for "ghost fishing", defined as the continued capture of fish and invertebrates. This is particularly true when floats and anchors are removed and only net mesh attached to the lead or float line remains. During the 1989-90 season, the crew of the Department's Patrol Vessel Chinook recovered 22 ghost nets. At this time the fishery was fishing up to 256 nets during each week of the season. Changes to the management of the fishery have contributed to the reduction in the potential for ghost fishing. The amount of gill net gear in San Francisco Bay was reduced by 50% beginning with the 1993-94 season, when regulations were enacted limiting each permittee to one net, 65 ftms (one shackle) in length. The number of actively fished nets has been at most 68 nets each week in the last ten years, and in many years the number of nets deployed was far less (Appendix J). In addition, the current fishery is heavily monitored, and nets are required to be marked with buoys and permit numbers. For these reasons the risk from ghost fishing has been greatly reduced.

5.10 Management Measures to Prevent Habitat Damage

5.10.1 Mitigating Habitat Threats from Fishing Activities

Gill nets are set in shallow waters (typically less than 20 ft deep) (6 m) and anchored at both ends to prevent them from moving. Set gill net gear is thought to have minimal impacts on habitat associated with each fishing area. However, anchors and nets both have the potential to disturb the bottom, affecting bottom dwelling, benthic species as well as subtidal vegetation. However, the soft-bottom benthic communities where Herring sac-roe and HEOK fisheries occur are dynamic, and are likely to recover quickly from disturbances provided they are not continuous (Herrgesell and others, 1983).

The potential for individual organisms or vegetation (particularly eelgrass) to be damaged is recognized, but no data exist to quantify those impacts. Gill net fishing for Herring is not allowed in a number of areas in San Francisco Bay, including in Richardson Bay and Belvedere Cove, which support subtidal eelgrass habitat and where the majority of Herring spawns have taken place (Figure 5-3, Section 5.5). These closures and boundaries prevent gill net fishing for Herring in approximately 361 acres (146 hectares) of total 2,790 acres (1,129 hectares) of eelgrass in San Francisco Bay, based on the most recent eelgrass habitat estimates (Merkel and Associates, 2014). This is roughly 13% of total eelgrass habitat present in the entire San Francisco Bay. However, eelgrass beds in other areas are vulnerable to disturbance by gill net gear. Areas where fishing is intense could suffer the greatest short-term adverse effects, although the limited depths associated with eelgrass beds provide some limitation on fishing pressure in those areas. The reduction in the active fleet size over the last 15 years has likely reduced the impact of fishing nets on benthic habitats.

The rafts and cork lines used in the HEOK fishery to suspend kelp can be deployed in Richardson Bay, Belvedere Cove and other areas of the bay. They must however be tied to permanent structures. While this requirement was originally implemented to facilitate HEOK regulation enforcement, it also provides protection to eelgrass beds from raft anchors (the rafts themselves do not come in contact with the bottom). The HEOK fishery may also affect the surrounding habitat by releasing kelp blades into the water during and after fishing. Giant kelp does not occur in significant quantities in San Francisco Bay, and kelp blades released by HEOK fishing have been shown to break down within 20-30 days, with faster deterioration occurring when temperatures are higher or in areas of lower salinity (Azat, 2003).

5.10.2 Mitigating Habitat Threats from Non-Fishing Activities

Given the unique life history of Herring, the primary threats to Herring habitat are from non-fishing activities that occur in the bays where Herring spawn each winter (Section 2.13.3). The Department has authority to manage habitat threats from fishing and non-fishing sources as a trustee agency. As a trustee for the State's fish and wildlife resources, the Department has jurisdiction over the conservation, protection and management of fish, wildlife, and habitats necessary for biologically sustainable populations of those species (FGC §1802). In this capacity, the Department administers the CESA, the Native Plant Protection Act, and other provisions of the FGC that afford protection to the State's fish and wildlife resources.

Primarily, there are two different processes through which the Department provides input on projects that may impact spawning Herring and habitat. The first is the interagency consultation process (Section 5.10.2.1), and the second is the CEQA process (Section 5.10.2.2).

5.10.2.1 Environmental Work Windows and the Interagency Consultation Process

Through the interagency consultation process, the Department provides input on projects that include in-water work that may result in environmental impacts, including to spawning Herring and habitat.

One of the primary threats to Herring spawning habitat is dredging in areas used by Herring during the spawning season. Dredging and dredge material disposal causes sediment to be suspended in the water column, which can affect Herring in a variety of ways. Increased turbidity, smothered eggs, and interference with larval development are some of the documented impacts (Griffin and others, 2012). These threats are mitigated via environmental work windows, which are temporal constraints placed upon dredging or dredged material disposal activities. The work windows were created to minimize environmental impacts by limiting dredging activities to time periods when biological resources are not present or when they are least sensitive to disturbance.

Work windows control dredging activities in all of the Herring fishery management areas, though the process may be best illustrated via the San Francisco Bay Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS). The LTMS was adopted in 2001, and represents a cohesive strategy amongst regional, state, and federal agencies with jurisdiction over dredging and development in San Francisco Bay waters to minimize environmental impacts. Under the LTMS, the primary mitigation method for impacts to Herring or Herring habitat in San Francisco Bay is via environmental work windows. Any project proposing to conduct dredging activities outside of the LTMS environmental work windows is required to undertake either informal or formal consultation with the appropriate resource agencies (National Oceanic and Atmospheric Administration Fisheries (NOAA), United States Fish and Wildlife Service, or the Department).

Consultation allows these agencies to consider the potential adverse effects from dredging and disposal to species that are protected by the designated work windows. Consultation is required for any project operating between December 1 and March 15 within the Herring spawning season. If there is a delay in project completion, a waiver can be requested to allow the project to continue during the work window. Under this process, when permitting agencies are considering whether to approve a project that may disturb Herring spawning habitat, they request comments from Department staff to assist them in evaluating the impacts of allowing the project to proceed. Department staff evaluate the proposed project and determine whether the project is likely to impact a Herring spawning aggregation. If the Department determines that the project may impact Herring or its spawning habitat, the Department will recommend that the project be modified, delayed to avoid any potential impacts, or issue a work window waiver with specific conditions.

If a waiver is granted, the Department imposes conditions associated with it in order to minimize impacts should Herring spawn near the project. These conditions include, but are not limited to, the following:

- Projects are required to have an independent biological observer present to look for Herring spawning activity. These observers are trained by Department staff, and are required to report weekly on their observations.
- If Herring are observed within 500 m (1,640 ft) of a dredging project work must stop.
- Shore-line surveys are required daily or after every eight hours of inactivity at the dredging location.

The number of waivers granted varies each year, but has ranged between five and 12 since 2013. Most waivers are issued for dredging activities and some for in-water work requiring pile driving or sediment core removal. The length of waivers typically ranges from one day to through the entire spawning season. Locations have included Redwood City Harbor, Oakland Harbor, Port of San Francisco and Richmond Harbor.

5.10.2.2 California Environmental Quality Act Consultation Process

By California law, all new projects are required to go through the CEQA process to inform decision makers and the public about the potential significant environmental impacts of proposed activities, and identify ways that potential significant environmental impact(s) can be avoided or significantly reduced. If a project is deemed to have potentially significant environmental impacts, the lead agency must complete an EIR with a description of the project, its anticipated impacts, and any steps to mitigate those impacts. The EIR is distributed to state, regional, and local agencies for comment. Through this process, the Department, as a trustee agency, is able to evaluate a proposed project's impacts on Herring or its habitat. The lead agency considering the project must respond to the comment in the EIR. If the Department finds the project is likely to have adverse effects that are not properly mitigated, the lead agency may be required to alter the proposed projects alternatives to reduce impacts.

5.11 History of Regulatory Authority and Process for Regulatory Changes

When the fishery began in 1972-73, concern about the effects of a large unrestricted fishery on Herring stocks motivated a state senator from the San Francisco Bay area to introduce emergency legislation giving the Legislature temporary control over the Herring fishery (Spratt, 1992). The Legislature recognized that fish that aggregate during their spawning season are uniquely vulnerable to overfishing. A cautious management approach was chosen, and conservative catch quotas were set for the first three Herring seasons. This allowed the Department to conduct a two-year study to assess the size of the Herring population and develop a framework for setting sustainable quotas. The Legislature controlled Herring quotas for the first three seasons, before granting management authority of the Herring fishery in all four fishing areas to the Commission in 1975. For a discussion of changes to quota-setting authority established by this FMP, see Sections 7.9 and 9.1.

5.11.1 The California Fish and Game Commission Regulatory Process

Prior to the adoption of this FMP, the San Francisco Bay commercial quota was adjusted annually through a Commission regulatory process. The Commission comprises five governor-appointed members who are confirmed by the Legislature. All changes to the management of the Herring fishery was done through a rulemaking process (governed by the California Administrative Procedure Act, or APA), requiring formal noticing and public comment processes before being approved by the Commission. This annual cycle takes months to complete and many hours of staff time to develop proposals and meet rulemaking process requirements.

The annual quota setting and regulation development cycle began just after the completion of the Herring season. Department staff analyze the data collected from spawn deposition surveys, research catch surveys, and commercial catch sampling to prepare a season summary. This summary describes the number of spawns, locations surveyed, the age structure, length structure, and condition of the stock. An estimate of the total spawning biomass and information on the total catch and roe percentages is included. Department staff present this information to the Director's Herring Advisory Committee (DHAC) in March or April each year. The DHAC has historically been composed of representatives from each of the different sectors of the fishery, as well as Herring buyer representatives. The purpose of DHAC meetings is to review the status of the fishery and for the Department to propose management changes (quotas and regulations) in advance of the annual rulemaking process. Department staff draft alternatives for management changes based on the feedback provided by the DHAC. The Department recommendations (proposals) are brought before the Commission for consideration and adoption as a rulemaking using the APA. This process is open to the public and interested stakeholders.

During the rulemaking process, a document on the environmental impact of the proposed changes is also drafted under CEQA. The Department initiates a broader consultation by distributing a NOP announcing the intent to prepare the CEQA document. The NOP is distributed to members of the public, responsible agencies, and organizations that have an interest in Herring management. The Commission considers all comments submitted during the notification and review process, then selects one of the management alternatives described in the DED. The Commission votes on whether or not to approve changes in the fishery and adopts new regulations through the rulemaking described above. A FED is approved and all comments received are appended to the final document. The Office of Administrative Law reviews the regulations and sets an effective date.

5.12 San Francisco Bay Stock Assessment Model Development

In 2011, with funding provided by the SFBHRA, the Department contracted with scientists at Cefas to develop a stock assessment model for the Herring population in San Francisco Bay (Appendix B). Cefas developed and fit an age-structured population model to available data on the San Francisco Bay Herring stock. This stock assessment formed the basis for an operating model that was intended to be used to evaluate the expected impacts of various management decisions going forward as part of a Management Strategy Evaluation (MSE) framework. It was anticipated that this analysis would be used in developing a HCR as part of an adaptive management approach during development of the FMP for the Herring fishery.

Following the stock assessment peer review, the reviewers concluded that they could not recommend its use as a method for estimating biomass and setting quotas for the commercial Herring fishery in San Francisco Bay without further model development (Appendix B). This was partly because the model that best fit the available data (the preferred model) did not reflect current understanding of Herring stock dynamics. The modeling exercise and review highlighted the level of uncertainty about the dynamics of the San Francisco Bay stock and the inability to base management decisions on any single model. The reviewers emphasized the following areas of concern with the Cefas model and associated data:

- inability to establish a defensible stock recruitment relationship,
- lack of empirical support for various mortality factors used,
- unresolved issues related to gear selectivity at age, and
- over-weighting of age composition data inputs relative to YOY-based recruitment and spawn deposition-based SSB indices.

The reviewers also recommended that the model not be used as the base model for the MSE analysis, but as one of a number of uncertainty scenarios. The Department accepted the recommendations of the review panel and agreed that the deficiencies in the Cefas model, identified above, could lead to the overexploitation of the Herring stock if adopted as a management tool. The Department followed the review panel's recommendation and used Cefas' preferred model (Model 6) as one of a range of operating models representing alternative hypotheses of how the stock functions as part of an MSE.

The results of Cefas' model development and review, as well as the discussions between Department staff, the review panel and Cefas scientists, have provided valuable insight into San Francisco Bay population dynamics. They have also helped identify which areas still represent major uncertainties, which have informed the MSE work for testing the HCR (Chapter 7, Appendix M).

Chapter 6. Monitoring and Essential Fishery Information

The MLMA requires the Department to develop FMPs that are based on the best available science (FGC §7072(b)) and include the relevant Essential Fishery Information (EFI). EFI helps to manage a fish stock sustainably, and the amount and type of EFI for a given stock will depend on a number of factors. These factors include, but are not limited to, the biology and life history strategy of the stock, the socioeconomic value of the fishery, the management objectives for that stock, and the availability of information that can be derived from past and current monitoring efforts. This chapter describes the history of monitoring in each of California's commercial Herring fishery areas, the EFI produced by these monitoring efforts, and how the monitoring protocols in those areas have evolved over time. It outlines EFI for commercial Herring management in California by type, how each is used in management, and its priority level (Table 6-1). Finally, this chapter identifies gaps in EFI for Herring and outlines potential monitoring protocols to address those information gaps through future research.

Table 6-1. EFI for the management of Herring, use of that EFI, and priority level.

Type of EFI Produced	Priority for Management	How EFI is used in management
Spawn Deposition Surveys		
Annual fall/winter-season vegetation densities for spawning areas	High	Used in conjunction with estimated fecundity and other Spawn Deposition Survey EFI to calculate annual abundance (biomass) of spawning stock
Dates, locations, and area estimates for each observed spawning event (shoreline and subtidal)	High	Used in conjunction with estimated fecundity and other Spawn Deposition Survey EFI to calculate annual abundance (biomass) of spawning stock
Egg density per kilogram of spawned substrate for each spawning event	High	Used in conjunction with estimated fecundity and other Spawn Deposition Survey EFI to calculate annual abundance (biomass) of spawning stock
Commercial Catch Monitoring		
In-season catch	High	Used to determine when the quota has been reached
Total removals	High	Added to biomass estimate from spawn deposition surveys to determine total spawning biomass for the season
Commercial Catch Sampling		
Age and size (weight and length) distribution of the commercial catch	Medium	Used to understand selectivity of the gear, potential recruitment issues

Weight-at-age of the commercial catch	Medium	Used to estimate the removals at age and to understand the selectivity of the gear in terms of age, helps determine fishery impacts on age structure of the stock
Research Trawl Surveys		
Research catch at age	High	Used to monitor the age structure of the spawning population
Sex ratio of each spawning wave/event	Low	Used to calculate final SSB estimate
Bay Study Trawl Survey Program		
CPUE of YOY Herring in bay	High	Provides information on the number of recruits each year, which is an index of the productivity of the stock
Spatial distribution of YOY Herring	Low	Provides information on juvenile habitat for Herring
Biological Information		
Average fecundity of spawning adult Herring	High	Used to convert observed eggs per m^2 to Herring biomass each year
Environmental and Ecological Information		
July-Sept sea surface temperature from buoy N26	High	Used in predictive model to estimate Herring SSB
Alternative forage indicators as tracked by the CCIEA program	High	Used to determine whether ecosystem-based quota adjustment is warranted
Unusual mortality events of Herring predators	High	Used to determine whether ecosystem-based quota adjustment is warranted

6.1 Description of Essential Fishery Information and Research Protocol

The Department initiated seasonal monitoring programs in San Francisco and Tomales Bays when the sac-roe fishery began in 1973. The primary aim of this monitoring program was to estimate population abundance in terms of the weight of the annual SSB in each bay, but additional metrics on the age and size structure of the stock were also collected (Spratt, 1981). A number of studies were conducted during the early years of the fishery to understand the biology of those stocks (Rabin and Barnhart, 1986; Spratt, 1981). Intermittent monitoring was also conducted in Humboldt Bay to estimate the size of that stock, and no monitoring had been conducted in Crescent City Harbor until 2015-16, when a limited monitoring effort commenced.

6.1.1 Fishery-Dependent Monitoring

6.1.1.1 In-Season Landings

Tracking commercial catch in near-real time is essential to successfully managing a quota fishery. In most fisheries, landings are tracked via landing receipts, but there is often a lag between the time of landing and the time at which these receipts are received by the Department and entered into the landings database. In order to monitor landings in real-time, Herring buyers report daily landing totals directly to Department fishery managers. The E-tix landings reporting system (online July 1, 2019) will allow for near real-time quota tracking. This assists Department staff in maintaining catch records within season and effectively determining when the commercial fleet has reached its quota and the fishery should be closed.

6.1.1.2 Total Commercial Landings

Commercial landings data (reported in short tons) has been collected via landing receipts each season since the fishery began in the winter of 1972-73. Historically, quotas were set for the different commercial fishery sectors, necessitating the need to track landings by individual gear type.

6.1.1.3 Commercial Catch Sampling

The Department began sampling the commercial catch in San Francisco Bay and Tomales Bay in 1973-74 (Spratt, 1981). Due to the difference in selectivity between commercial gear types, each sector of the fishery is sampled separately. Commercial catch is sampled from each spawning wave that is fished in order to capture temporal variability in catch composition. Each sample consists of approximately 20 fish taken from a commercial vessel during fishing operations or during offloading. Up to ten samples are taken per wave of spawning fish, though fewer commercial samples may be available in smaller spawning waves or when fewer vessels are participating in the fishery. When collecting samples, the vessel name and date of the landing is recorded. For each fish, length (in mm), weight (to the nearest 0.1g), sex, and maturity are recorded, and the otoliths are removed. Spent or immature fish are rare in the commercial samples, but they are included when encountered.

Otoliths collected from commercial samples are aged by Department staff at the end of each season. The age-structure information obtained from the commercial catch samples is used to calculate commercial catch-at-age in terms of numbers and weight for each gear type in each landings event.

6.1.2 Fishery Independent Monitoring

6.1.2.1 Spawn Deposition Surveys in San Francisco Bay

Since the 1973-74 season, Department staff have surveyed egg deposition from all observed spawning waves (Spratt, 1981; Watters and Oda, 2002). For each spawn event, the number of eggs laid is converted to the biomass of adult Herring that must have been present to lay that number of eggs. These estimates of biomass are summed and then added to the total landings data to provide an estimate of the total SSB (in short tons) for each spawning season. During the early years of the fishery, the sampling protocol evolved to meet management needs as they became apparent. Since the 1982-83 season a standardized protocol has been used with only minor modifications made in response to the expansion of Herring spawning season and changes in the spatial distribution of spawn events over time (Watters and Oda, 2002).

Intertidal Spawn Sampling Protocol

Beginning with the 1973-74 season, searches for intertidal Herring spawn activity have been conducted from a small boat approximately four days per week during low tide periods, from December to mid-March (Spratt, 1981; Watters and Oda, 2002). When intertidal spawns are located, the area of the spawn is estimated and eggs are collected to calculate the average egg deposition density for the area. Spratt (1981) contains a detailed description of the intertidal sampling protocol.

Beginning in 1981-82 Herring were also observed to spawn on pier pilings. Pier pilings are sampled using a protocol similar to that for intertidal spawns (Spratt, 1984). During the 1982-83 season the methods used to convert the number of eggs spawned to tons of Herring was altered to include information on the sex ratio for individual spawning runs, improving the accuracy of the estimate (Spratt, 1984).

Subtidal Spawn Sampling Protocol

Prior to the 1978-79 season, only intertidal spawns were sampled, therefore SSB estimates from these years are likely an underestimation of the stock size. Beginning in 1979-80, subtidal spawns have been sampled as well, providing a more accurate estimate of the yearly SSB. Subtidal vegetation samples are collected via SCUBA, prior to the season from spatially-random sampling locations within beds composed primarily *Gracilaria* spp., and eelgrass, at known spawning areas around the bay. At each sample site, scuba divers collect one sample from each of four 0.25 m^2 quadrats. Samples are processed in the lab, weighed, and averaged to estimate vegetation biomass (kg/m^2).

When a spawning event occurs, a rake is deployed at regular intervals throughout the bed to determine the extent of the spawning area using the Global Positioning System. As with the intertidal spawn samples, the subtidal sample is processed in the lab to calculate the number of eggs per kilogram of vegetation. These data, along with estimated vegetation biomass and estimated extent of the spawning area, are used to calculate the total number of eggs, which is then converted to short tons of adult Herring based on the average fecundity per gram of Herring (Section 3.12) (Watters and Oda, 2002).

6.1.2.2 Spawn Deposition Surveys in the Northern Fishery Areas

Tomales Bay

During the 1973-74 season Department staff began spawn deposition surveys in Tomales Bay using the subtidal sampling protocol on eelgrass beds, the principal spawning substrate in Tomales Bay (Spratt, 1981). Spawn deposition surveys continued through the 2005-06 season, after which time they were discontinued due to staffing constraints. During the 2006-07 season, limited monitoring was undertaken in preferred spawning areas when time and weather permitted, and the dates and locations of spawns were recorded. This was also the last year that commercial fishing occurred in Tomales Bay.

Humboldt Bay

Herring spawning biomass was surveyed during 1974-75, 1975-76, 1990-91, 1991-92, and from the 2000-01 through the 2006-07 seasons using the subtidal sampling protocol (Rabin and Barnhart, 1986; Spratt and others, 1992). Herring spawn occurs on the extensive eelgrass beds in both the northern and southern portions of Humboldt Bay, with the North Bay typically receiving the most spawning activity. Surveys were discontinued after the 2006-07 season due to staffing constraints and lack of fishing effort. Although SSB has not been calculated for the Humboldt Bay stock since 2007, monitoring to evaluate population characteristics and determine spawn timing and spatial extent, resumed in 2014-15.

Crescent City Harbor

No spawn deposition surveys have been conducted in this area. However, limited monitoring of spawn timing and spatial extent began in 2015-16.

6.1.2.3 Hydro-acoustic Surveys for Estimating SSB in San Francisco Bay

Between 1982-83 and 2001-02, the Department conducted hydro-acoustic surveys in San Francisco Bay to explore an alternative method for estimating SSB (Watters and Oda, 1997). These surveys primarily occurred in the deeper waters of the bay over Herring schools prior to spawning. Surveys occurred up to four days a week during the spawning season on slack tides (typically high slack) to reduce error due to tide-related school movement. Schools were initially found and qualitatively surveyed with a fish finder. Herring-like marks were confirmed by sampling the school with a midwater trawl. Once the school was verified as Herring, quantitative hydro-acoustic surveys were conducted with a Raytheon model DE-719B paper recording fathometer. Biomass was estimated for each school from paper traces using the 'visual integration' method (Reilly and Moore, 1983).

Beginning in 1989-90 season, the protocol for estimating SSB (calculation from spawn deposition surveys) was revised to incorporate the hydro-acoustic surveys. For each Herring school observed during the season, the estimates of biomass from each of the two survey methods were compared. If one survey was missing, the other was used. If the two estimates were similar they were averaged. If Department staff had more confidence in one survey than the other, that survey result was used, and if there was equal confidence in both surveys, the higher estimate was usually chosen (Spratt and others, 1992). The chosen estimates for each school were then summed to determine a final biomass estimate for the season (Figure 6-1).

Beginning in the late 1990s the hydro-acoustic and spawn deposition survey estimates began to diverge, with the spawn deposition surveys showing declines in stock size. During the 2002-03 season the SSB could not be estimated due to a substantial divergence between the spawn deposition and hydro-acoustic surveys (Figure 6-1). As a result, the Department initiated a review of the survey methods used (Appendix I). This study examined how well the spawning biomass estimates from each method correlated with the following year's spawn deposition estimate. The review found that while the spawning deposition surveys could explain 50% of the variation seen from year to year, the hydro-acoustic surveys could only explain 4%. Based on the results of this study the Department discontinued the hydro-acoustic surveys and continued only using the spawning deposition surveys to estimate biomass and set quotas.

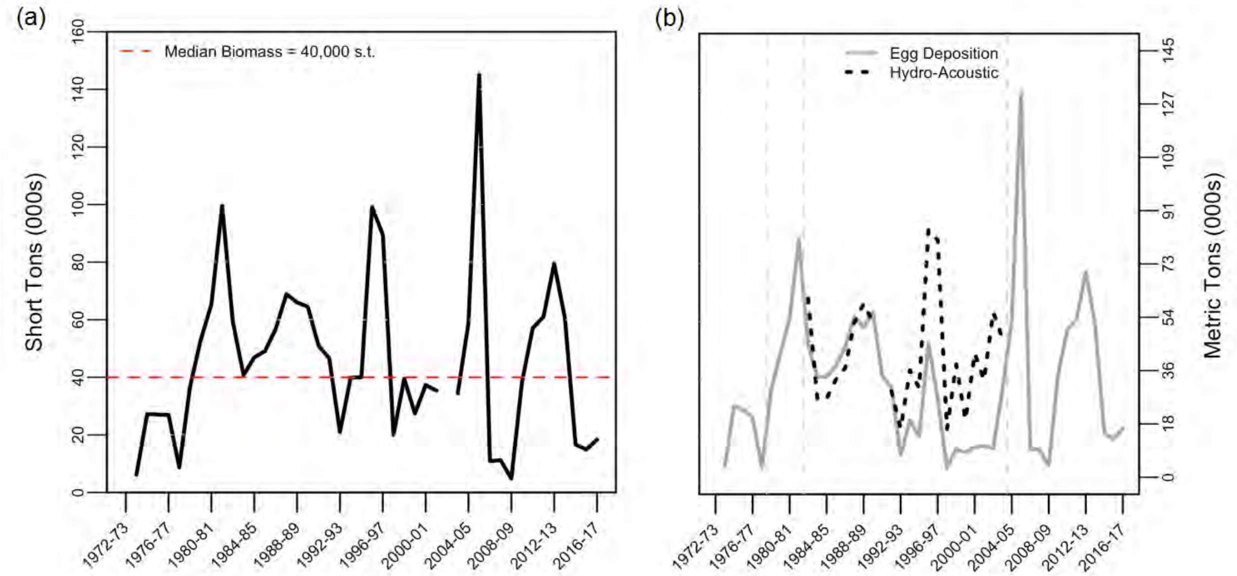

Figure 6-1. Department estimated yearly SSB of San Francisco Bay Herring between 1972-73 to 2016-17 in short and metric tons. The left panel (a) shows the reported biomass (with a median biomass of 40 Kt/36 Kmt), and the right panel (b) shows the individual biomass estimates from the spawn deposition and hydro-acoustic surveys. Dates corresponding to changes in the survey methodology are indicated by light blue vertical lines.

6.1.2.4 San Francisco Bay Study Midwater Trawl Young of the Year Survey

Data on the number of age zero, one, and two or older Herring throughout the year in San Francisco Bay are available as part of the Department's Bay Study Program (Baxter and others, 1999). This program began in 1980 with the goal of determining the trends in environmental variables and the distribution and abundance of living resources in San Francisco Bay. A Department research vessel operates a midwater trawl and an otter trawl monthly, year-round at each of 52 open-water sampling locations. These locations range from southern San Francisco Bay through San Pablo and Suisun Bays and into the Delta (Figure 6-2).

Juvenile Herring are caught in the midwater trawl, and this survey produces monthly CPUE (number caught/tow volume*10,000) of age zero, one and two or older fishes. Age zero fish are most prevalent in the trawl catch during the months of April to July, and less prevalent from August onward, when they are likely to have started moving out of the bay to ocean waters. The CPUE of YOY Herring was found to be significantly correlated to the observed SSB three years later (Roel and others, 2016; Sydeman and others, 2018) and data from this survey provide one of the key indicators used to predict SSB (Section 7.6.2). As a result, these data serve as a core component to the management strategy for Herring proposed in this FMP.

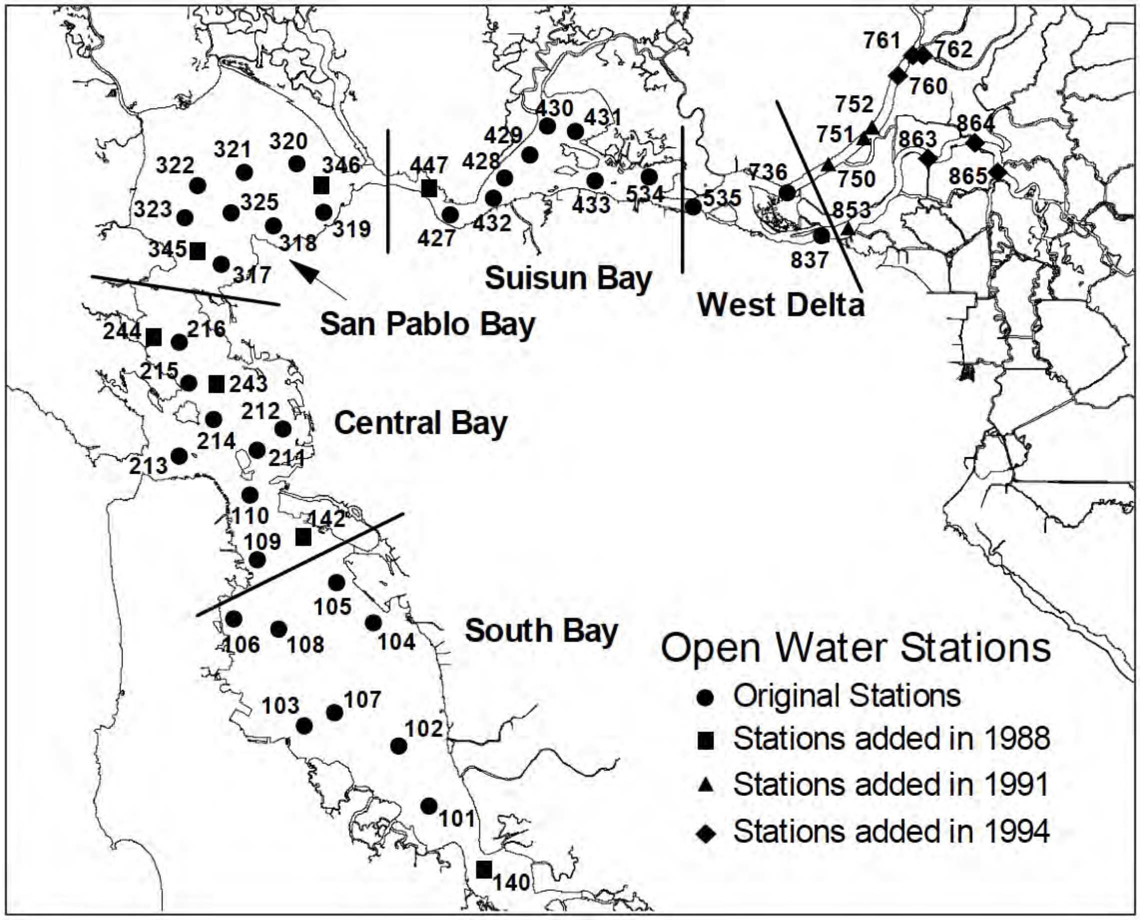

Figure 6-2. Station map for San Francisco Bay Department midwater trawls, from which YOY Herring abundance data are obtained.

6.1.2.5 Herring Research Midwater Trawl Survey in San Francisco Bay

The Department has used a midwater trawl to sample the population in San Francisco Bay since the 1982-83 season. Surveys usually begin in late-November or early December, when Herring schools start moving into the bay in spawning waves, and usually end in March. Trawl samples are taken roughly once a week throughout this time period using the Department's research vessel, with the goal of sampling every spawning wave that enters the bay prior to a spawn occurring. This sampling resolution provides information on the spatial and temporal variability of spawning waves during each season. Department staff transit the bay using a fathometer to detect Herring schools, and opportunistically sample each school using the midwater trawl. A typical population sample obtained via this method comprises anywhere from a minimum of 30 to a maximum of 200 individual Herring.

6.1.2.6 Multi-panel Gill net Survey in San Francisco and Tomales Bays

A midwater trawl is the primary method for obtaining population samples from spawning waves in San Francisco Bay. However, multi-panel gill nets are also used as a supplemental technique when the midwater trawl vessel is unavailable or in areas that are too shallow for the midwater trawl gear to operate. The research gill nets are constructed of varying mesh sizes, including 1.5, 1.75, 2.0, 2.25, and 2.5-in (38, 44, 50, 57, and 64 mm) to sample the entire range of Herring sizes present in the population. The research net is able to capture younger age classes than the commercial fishery due to the minimum commercial mesh regulation of 2.0-in (50 mm). The Department also employed research gill nets in Tomales Bay prior to ending the surveys in 2006-07.

6.1.2.7 Population Data Collection

Population samples obtained via the midwater trawl and multi-panel gill net surveys compose the research catch for a given season. The research catch is the Department's source of demographic data for that season's SSB. Length and gonad maturity data are recorded for all sampled fish. Immature and spent fish are discarded, and mature fish are weighed and otoliths are removed. Note that Herring typically do not spawn until age two or three so there are few age one fish in the research catch-at-age data.

Surface reading of otoliths are completed at the end of the season by Department staff. The resulting age data are used to calculate raw numbers at age and weight at age for each spawning wave. The raw numbers-at-age are then weighted by the estimated size of the spawning wave and then summed over all waves to estimate the total numbers-at-age in the spawning stock. This wave-by-wave analysis is necessary because each spawning wave may have different sex ratios or age compositions. Weighted numbers-at-age data are available from 1982-83 on with the exception of the 1990-91 and 2002-03 seasons. During these seasons, the spawning stock numbers-at-age data were not available due to incomplete datasets. From the 1982-83 season to 2003-04 a subsample of Herring from the fishery-independent samples was aged and a key was constructed annually based on those ages, which was applied to the entire catch to characterize the age composition of the SSB (Reilly and Moore, 1983). However, in 2003 an independent review committee recommended direct aging (MacCall and others, 2003). Since that time the Department has aged a sub-set of each spawning wave to assign age composition.

6.1.2.8 Collaborative Research

The SFBHRA was formed in 2009 with funds made available from the responsible party following the Cosco Busan oil spill (November 2007). The SFBHRA is a non-profit fishing industry group dedicated to working with the Department to assist in monitoring the San Francisco Bay Herring stock. A collaborative monitoring protocol was developed to assist Department staff in tracking Herring schools and locations of Herring spawning activity. Spawn surveys are conducted at regular intervals through close coordination with Department staff. SFBHRA members follow a streamlined spawn deposition sampling protocol and collect adult Herring using the same multi-panel research gill net described above. Samples are provided to Department staff for processing and inclusion into existing datasets.

In Humboldt Bay, another collaborative research program has been active since the 2014-15 season. This collaboration was also developed and supported by local fisherman to assist Department staff in updating information related to stock status in Humboldt Bay for Herring. Beginning in late 2014, this effort has helped to monitor the approximate size, number, and location of spawn events, as well as to conduct biological sampling. This collaboration has helped to improve the Department's understanding of the Herring resource in Humboldt Bay, which has historically only had intermittent research and monitoring.

6.1.2.9 California Recreational Fisheries Survey

As part of the California Recreational Fisheries Survey (CRFS), Department personnel intercept recreational anglers at boat ramps, on commercial passenger fishing vessels, at man-made structures, and along beaches and banks in order to collect catch and effort data[4]. Because Herring aggregate during spawning events, recreational catch can be very high for a short period of time, and thus CPUE may not be indicative of abundance. Catch data from CRFS monitoring is useful to begin to understand the extent of recreational take and gear types used in the fishery. Unfortunately, due to the unpredictable nature of spawning activity and the low likelihood of encountering recreational anglers targeting Herring, only a few interceptions have been made.

6.2 EFI Needs and Future Management Options

Additional EFI data are necessary for effectively monitoring the Herring resource. Table 6-2 identifies EFI gaps for California Herring. The abundance of the spawning stock in terms of biomass is the primary type of EFI required for sustainable management of the Herring fishery in California, but this information is currently missing for the management areas outside of San Francisco Bay. Spawn deposition survey methodologies that have been applied in the past obtain the best estimates of absolute SSB on an annual basis. However, these surveys are resource intensive and may not be appropriate for relatively small-scale fisheries with a limited number of participants. The MLMA 2018 Master Plan for Fisheries directs managers to scale monitoring and management activities relative to the value of the fishery and the risk to the stock (California

[4] The CRFS Sampler Manual (available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=62348&inline) describes the history of the survey, general information, methods, and the roles and responsibilities of supervisors, leads, and samplers.

Department of Fish and Wildlife, 2018). However, Herring stock abundance can vary widely from year to year and applying the existing spawn deposition surveys less frequently may increase risks to the stock and the sustainability of the fishery. Instead, the consistent application of a less intensive survey method that results in a proxy for spawning stock abundance is more appropriate for monitoring smaller Herring fisheries. This section describes a potential research protocol to fill this gap. It also highlights other monitoring opportunities for Herring.

Table 6-2. EFI gaps for Herring and their priority for management.

EFI Type	Priority for Management	How EFI would support future management
Fishery Independent		
Index of abundance in unfished management areas	Medium	Implementing Rapid Spawn Assessment Method would inform quota setting should fishing resume in these areas.
YOY abundance	Medium	Ensuring completion of annual surveys allows for use of predictive statistical model, which relies on indices of abundance of YOY, for SSB estimation.
Fecundity	Medium	Frequent fecundity estimates increase accuracy of spawning biomass estimates derived from egg deposition surveys.
Maturity at age	Low	Up-to-date maturity-at-age estimates could inform future attempts at stock assessment.
Population structure	Medium	State-wide population structure, including timing and geography of spawn events and genetic structure, may help inform whether spatial or temporal considerations in management are necessary
Fishery Dependent		
In-season commercial catch outside San Francisco Bay	High	Inform managers on level of take achieved and when to close if fishing resumes in management areas outside SF Bay.
Age distribution of any catch outside San Francisco Bay	Medium	Age distribution of catch can provide managers with secondary indicator of stock status.
Size distribution of any catch outside San Francisco Bay	Medium	Size distribution of catch can provide managers with a secondary indicator of stock status.
Recreational catch estimates	Low	Provide managers with tools to better regulate recreational fishing in all management areas.

6.2.1 Index of Abundance in Unfished Management Areas

A current gap in EFI is the lack of active monitoring programs for assessing Herring spawning populations in management areas where commercial fishing activity does not occur, and the Department isn't investing staff resources in producing full SSB estimates (see Sections 7.2 through 7.6 and 8.1). Spawn surveys in Tomales and Humboldt Bays were discontinued after 2006-07 due to staffing and resource constraints. Due to low Herring roe prices and lack of processing facilities, at the time of FMP development, no commercial fishing has occurred in these areas since 2006-07 and 2004-05 respectively. Despite the lack of commercial fishing pressure, Herring are known to be very sensitive to fluctuations in environmental conditions, and the status of these stocks is unknown. Should fishing resume, it will be necessary to resume some level of monitoring to understand the impacts of fishing on the stock, and to avoid over-fishing during natural declines in productivity.

6.2.1.1 Rapid Spawn Assessment Method

To explore future management options, Department staff have been piloting a new sampling protocol in Humboldt Bay with the following objectives: 1) identify the number and timing of spawns, 2) identify the locations and extents of spawns, and 3) qualitatively assess spawn density if possible, depending on staff and collaborative resources. Information on numbers of spawns and spawning extents, along with locations and timing of those spawns, can be compared with historical information to inform fishery management decisions (Appendix P). This Rapid Spawn Assessment Method provides Department staff with a less intensive strategy to monitor the relative condition of stock status in management areas that are either unfished or fished at a low intensity.

6.2.1.2 Building Collaboration

Collaboration with key partners is a potentially useful tool to provide information in areas where the Department lacks the resources to monitor Herring populations. The Department has collaborated in the past and will continue to work with outside entities such as academic organizations, NGOs, citizen scientists, and both commercial and recreational fishery participants to help fill information gaps related to the management of state fisheries. The Department will also reach out to outside persons and agencies when appropriate while conducting or seeking new fisheries research required for the management of Herring. Several of the information gaps identified above (Table 6-2) are potential areas for collaboration. While the Rapid Spawn Assessment Method is primarily designed to be carried out by Department staff, its efficacy will be greatly aided by collaboration with fishermen and other interested parties. For example, Department staff can request that active fishermen voluntarily notify staff when they observe Herring spawning activity (time and location of spawn). This increased observational data will increase detection of spawns and allow the Department to better assess these events. As these partnerships are developed, fishermen may assist the Department by collecting samples to document spawn intensity through a collaborative research program. The program design could follow the successful collaboration between the SFBHRA and the Department.

6.2.2 Fishery-Dependent Monitoring

6.2.2.2 In-Season Catch Outside of San Francisco Bay

Should commercial fishing resume in areas outside of San Francisco Bay, fishery-dependent monitoring could help Department staff monitor the status of the stock. In-season catch levels will be monitored so that the fishery can be tracked and closed when it reaches its quota. Close communication between the Department and fishing industry will be critical to ensure catch targets are not exceeded. In areas where limited or no monitoring occurs, the licensed Herring buyers will notify the Department prior to landing Herring. Communication between Department staff and fishery participants will help track real-time fishing effort, and monitoring offloads will ensure quotas are closely adhered to in these areas. Department staff will be able to sample commercial catch and collect length and weight data. This information will help fishery managers monitor the catch for changes in size distribution, which may signal a need for management action.

6.2.2.3 Periodic Collection of Age Distribution Data Outside of San Francisco Bay

When resources are available, otoliths should be removed from commercial catch samples and aged to produce catch-at-age data and weight-at-age data. These can then be used to develop length-at-age and length-weight relationships for stocks in these periodically sampled areas. Surface reading of otoliths to determine fish ages is resource intensive but collecting and aging every few years will provide a check on stock condition and age distribution. For example, if fishery managers detect a loss of older age classes it may signal a need for management action depending on fishing activity levels in a given area.

6.2.2.4 Size Distribution Data in Areas Outside of San Francisco Bay

Size distribution in the commercial catch can be sampled opportunistically when fishing occurs in the northern management areas. Ideally, size distribution data could be collected annually and be used as a secondary indicator of stock status. Size-at-age is known to fluctuate in Herring due to environmental conditions, but it is possible to classify fish into size classes that provide an indicator of their approximate age (Cope and Punt, 2009). Monitoring the relative proportions of commercial catch in each category can provide fishery managers with important data on stock condition and changes in catch composition over time may suggest a need for additional research or a more precautionary management approach.

6.2.2.5 Accurate Recreational Catch Estimates

Currently, recreational removals are assumed to be a small proportion of the total catch each year. However, anecdotal reports from commercial and recreational fishermen as well as Department staff suggest that the catch from the recreational sector has been steadily increasing in recent years. There is also concern that large volumes of recreationally caught Herring may end up being sold as bait or for food, which is illegal under FGC §7121 (Unlawful sale or commercialization). Based on Department observations and CRFS catch estimates, annual take could range from 50 to 100 tons (45 to 91 metric tons). Given the nature of recreational fishing it would be difficult to obtain accurate catch estimates unless licensing or reporting requirements were changed.

Recreational anglers tend to target Herring spawning aggregations that are accessible from piers or the shoreline, and can spur intense fishing effort, with anglers participating in close proximity to one another. Currently, there is very little information on the number of recreational anglers because there are no licensing requirements or bag limits for the recreational take of Herring from public piers. While effort is not a useful indicator of Herring abundance, data on number of recreational participants in each bay could be used as a proxy for total recreational removals per season by assuming a constant catch amount per participant. The implementation of a daily bag limit (Section 7.8.7) provides a baseline assumption of daily catch and provides managers a simple tool to better regulate catch. An opportunistic sampling protocol, in which Department staff observe recreational fishery participants during a spawning event and estimated CPUE, could result in improved catch estimates, which would inform fishery managers and better address any future sustainability concerns.

Chapter 7. Management Strategy for California Herring

This chapter describes the Department's comprehensive and cohesive management strategy for Herring fishery, including: 1) monitor Herring populations in the four management areas (San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor), 2) analyze data collected via the monitoring protocol to estimate SSB, 3) develop quotas based on current SSB using a HCR, 4) track indicators to monitor ecosystem conditions, and 5) establish additional management measures to regulate fishing. This management strategy is based on an adaptive management framework that seeks to improve management through monitoring and evaluation, in order to better understand the interaction of different elements within marine systems[5].

The primary mechanism for ensuring stock sustainability in California's Herring management areas is to set precautionary limits on catch (quotas) using a harvest rate cap and a cutoff below which no harvest is allowed. For San Francisco Bay, quotas are set with the goal of achieving harvest rates that do not exceed 10% of the SSB, which is more precautionary than what is used in the management of other Herring fisheries such as in Alaska and British Columbia. However, given the changes in Herring stocks observed over the 45-year history of the sac-roe fishery, such precaution is warranted. Low harvest rates provide a buffer against scientific uncertainty, particularly during periods of high interannual variability in SSB, when the SSB is lower than predicted, or when poor environmental conditions may negatively affect stock size. Similarly, cutoffs prevent continued depletion and allow for rebuilding during low productivity periods. Low harvest rates also potentially allow more Herring to spawn successfully, protecting the spawning potential of the stock. Herring are an important forage species in the CCE and low harvest rates, as well as fishing closures when stock sizes are reduced below the cutoff, help increase the likelihood that the needs of these predators are met. The 10% target harvest rate cap and cutoff were agreed upon by a group of representatives from the commercial fishing industry and conservation NGOs during the development of this FMP. This continues the precautionary management approach the Department has employed since 2004 (Section 5.2.1.1).

Additional management measures are in place in San Francisco Bay to help ensure that commercial harvest targets primarily age four and older fish, that spawning aggregations receive temporal and spatial refuges from fishing, and to minimize interactions between fishermen and the other users of the bay. Lower harvest rates also help to protect the age structure of the stock, which

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[5] (California Fish and Game Code §90.1) "Adaptive management," in regard to a marine fishery, means a scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that even if they fail, they will provide useful information for future actions. Monitoring and evaluation shall be emphasized so that the interaction of different elements within the system can be better understood.

may in turn allow the stock to be more resilient to non-fishing impacts such as changes in environmental conditions or degradation of habitat. Recent analyses have shown that warm water events may result in lower survival of YOY Herring, and thus a smaller year class recruiting to the stock three years later (Appendix E). Maintaining a stock with a greater proportion of older fish may help to buffer the stock against those years when juvenile survival is poor. The age structure of the stock may also influence the timing and location of spawn events. Maintaining a diverse age structure may help ensure that spawning occurs throughout the historical spawning period and throughout the available spawning areas (Berkeley and others, 2004; Watters and others, 2004). The northern management areas also have precautionary quota recommendations based on a combination of historical SSB estimates and commercial catch data. Additionally, temporal and spatial closures as well as gear restrictions augment the precautionary approach in those areas.

7.1 Management Objectives

Fisheries are complex socio-ecological systems, and managers must ensure, to the extent possible, that target stocks can sustain themselves, while balancing the needs of the fishermen with the ecological role of the fished species. The management objectives for California’s Herring stocks were developed in recognition of these various, and at times competing, needs, and are described below.

7.1.1 Promote a healthy long-term average biomass

This objective recognizes the fact that Herring populations are most able to reproduce successfully, support a productive fishery, and provide forage to predators when they are at healthy levels. If the stock is not in a healthy state the Department is required to rebuild to achieve a healthy long term biomass.

7.1.2 Minimize the number of years stocks are in a depressed state

This objective recognizes that due to the population dynamics of Herring, natural fluctuations can result in low stock size even in the absence of fishing. However, with a responsive management system in place it is possible to detect these declines and reduce fishing pressure to avoid high harvest rates that may result in overfishing when stocks are low.

7.1.3 Maintain a healthy age structure

This objective recognizes that the stock is most sustainable when it comprises Herring from a variety of year classes, including recruits (age two and three), the age four and five fish that make up the majority of the commercial catch, and older fish (ages 6+).

7.1.4 Maintain an economically viable fishery

This objective recognizes that California's natural resources should be managed in order to maximize their long-term benefit to the State and its residents. This objective is multi-faceted and includes maximizing yield while maintaining stable quotas from year to year, minimizing the number of years with a zero quota to maintain access to markets, and matching the capacity of the fleet to the amount of take that the resource can sustain.

7.1.5 Help Ensure Herring remain an important component of the ecosystem

This objective recognizes that Herring are an important forage fish in the CCE, adheres to the Commission's forage species policy, and helps the Department in meeting the goals of the MLMA, principally, managing for non-consumptive values and helping to maintain intact ecosystems.

7.2 Tiered Management Approach

To ensure that target harvest rates are achieved despite the dynamic nature of Herring stocks, the Department estimates the size of the spawning stock and describes its age structure and condition annually in San Francisco Bay through spawn deposition and midwater trawl surveys. This fishing area has historically had the largest population and largest fishery, and at the time of FMP development, is the only management area with an active commercial fishery. Implementing these intensive surveys in all four management areas is not feasible due to resource and staffing constraints. When no commercial fishing effort occurs in a management area, there is no risk to those stocks from commercial fishing. However, should commercial fishing resume in a management area, it may be necessary to implement monitoring protocols that are sensitive enough to detect years when SSB is low and fishing could harm the stock. Therefore, a tiered management approach will help prioritize monitoring efforts and apply appropriate levels of management to fit the fishery activity level.

This section describes a tiered approach that scales management effort to the level of fishing effort and amount of information available for each management area. In this approach, areas with less fishing effort require less monitoring effort, and areas that have less information available have precautionary quota setting procedures with low maximum harvest rates available to them (Figure 7-1). This allows management to direct its resources proportionally, depending on the amount of fishing effort in that area in terms of catch or participation. This approach is also consistent with the Commission's forage species policy.

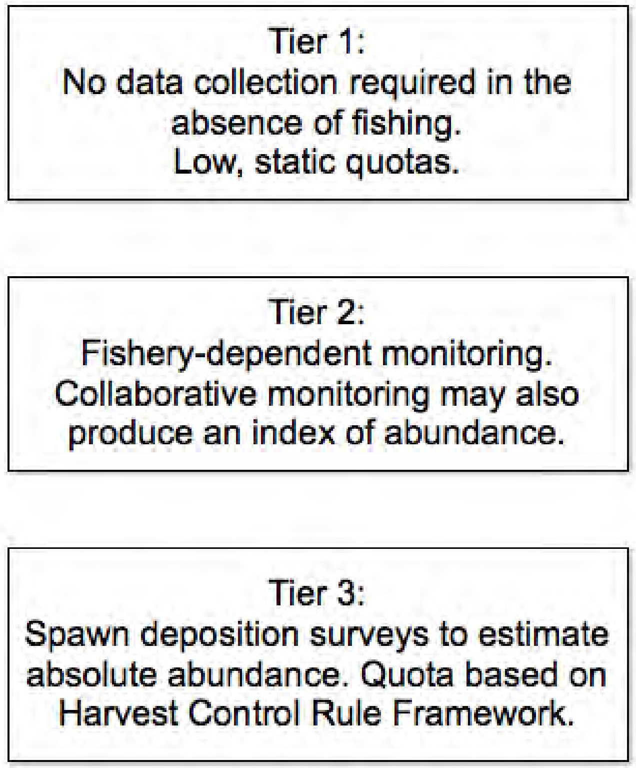

Figure 7-1. Schematic of tiered approach to Herring management, in which each management area falls into one of three tiers based on the level of fishing occurring. The level of monitoring effort is dictated by the size of the fishery, and the quota setting approach is determined by the information available.

7.3 Defining Management Tiers

In order to implement a tiered approach to management, it is necessary to define the management tiers and describe how management areas transition between tiers. This section describes the conditions that would necessitate assignment of a management area to a new tier level.

Tier 1 management areas are those areas where low, precautionary quotas are available, but no fishing has occurred in the prior season. These quotas are based on historical catch and/or SSB data for these areas. At the time of FMP development, Tomales Bay, Humboldt Bay, and Crescent City Harbor are Tier 1 management areas. No commercial fishing has taken place in these areas since 2005-06 or earlier.

If any Herring permits are fished in a Tier 1 management area, that area will be managed as a Tier 2 management area during the subsequent season (Section 7.5). The same quota is retained when an area transitions from Tier 1 to Tier 2. The differences between Tier 1 and 2 management are the collection of fishery-dependent data and the potential for collection of additional fishery-independent data via the Rapid Spawn Assessment Method (Section 6.2.1.1, Appendix P) or spawn-deposition survey (Section 6.1.2.1), and that Tier 2 may have a quota increase if additional fishery-independent monitoring is conducted (Section 7.5.2) and the Department deems that stock conditions warrant the increase (Section 7.5.3).

A Tier 2 management area becomes a Tier 3 management area when the Department determines that the size of the fishery in that management area, in terms of potential catch or the number of participants, warrants more intensive monitoring, including annual estimation of SSB and use of an HCR. This may occur due to increases in the ex-vessel price of Herring, resulting in increased utilization of existing permits and/or requests for new permits. Tier 3 management areas require a more comprehensive management protocol to promote sustainable harvest, as well as additional Department staff and resources. At the time of FMP development, San Francisco Bay is the only Tier 3 management area. However, should market or stock conditions change, it is possible that other management areas could become Tier 3 management areas. It is important to note that many aspects of the Tier 3 management area HCR framework described in this chapter were developed using data from San Francisco Bay, which lies within the central California region of the CCE. A change to a higher tier level in the other three management areas may also require a HCR that is specifically parameterized for those individual stocks and environmental conditions.

A Tier 3 management area may also be assigned to a lower tier should effort decrease substantially or should commercial fishery activity cease altogether. During these periods of reduced fishing effort, low landings, or permit attrition, the Department may determine that, given the many competing priorities of staff, the fishery no longer warrants an intensive management system.

7.4 Tier 1 Management Areas

Fishery monitoring is designed to measure the impact of fishing on a stock, and to alert managers when fishing is likely to negatively impact the sustainability of the stock so that appropriate management actions can be taken to reduce those impacts. In management areas where no fishing has occurred in recent years, there is no monitoring required and no data are produced. As a result, no assessment methodology or quota adjustment is required. Such areas are considered Tier 1 management areas.

In Tier 1 management areas, the quota will remain set at a precautionary level that provides opportunity for fishing should economic or market conditions change. The Tier 1 quota for San Francisco Bay is 750 tons (680 metric tons), which is approximately 1.5% of the average historical SSB. Because recent SSB data were unavailable in the northern management areas during the drafting of this FMP, the Tier 1 quotas are set at levels that consider historical stock size, average historical catch, and the overall management framework. In Tomales Bay, where extensive historical biomass data are available, the quota for Tier 1 management is set at 133 tons (121 metric tons), which is approximately 3% of the average historical SSB estimate of 4,446 tons (4,033 metric tons). The Tier 1 quota for Humboldt Bay is set at 11 tons (10 metric tons), which is 3% of historical SSB estimate of 351 tons (318 metric tons). However, no SSB estimates were made for Crescent City Harbor prior to the drafting of this FMP. Consequently, developing Tier 1 quota ranges for this stock is more difficult. The Tier 1 quota for Crescent City Harbor is set at 11 tons (10 metric tons), which is 50% of the average historical landings and a 63% decrease from the quota prior to the adoption of this FMP. These are precautionary quotas that include buffers for the impacts that ecological changes may have had on the productivity of these stocks since they were last fished. The rationale for retaining these precautionary quotas in the absence of active fishing is to provide access to the resources should market conditions in these areas change. This also aligns with a goal outlined in the MLMA regarding fishing communities, which recognizes the long-term interest of fishing dependent communities, and aims to maintain fishing opportunities wherever possible.

7.5 Tier 2 Management Areas

The Tier 2 management strategy is designed to scale the amount of monitoring required by the Department to the level of fishing effort that occurs in an area, which will help determine the level of risk to the Herring stock associated with fishing. When a management area is assigned to Tier 2, the quota level from Tier 1 remains in effect, and the catch must be monitored via fishery-dependent monitoring protocols (Section 7.5.1). If spawn deposition surveys are conducted to produce an estimate of SSB (Section 7.5.2) and the Department deems that stock conditions warrant it, the quota may be adjusted for the following season (Section 7.5.3).

7.5.1 Fishery-Dependent Monitoring in Tier 2 Management Areas

In Tier 2 management areas, the Department monitors commercial catch. This includes monitoring landings to ensure that the fishery is closed when the quota has been reached, as well as collecting data to understand the size distribution of the catch when staff resources are available. The Department will also determine age class structure of the commercial catch through appropriate sampling when staff and resources allow, with a goal of sampling every five years. At the time of FMP development, management areas outside of San Francisco Bay (the three northern management areas) have not been subjected to commercial fishing since 2005-06 or earlier. During this time, stocks have likely returned to unfished age distributions. For this reason, sampling the age distribution before or concurrent with the resumption of fishing activities would provide a benchmark with which to assess the impacts of fishing on the age structure of the stock in the future.

Generally, age keys are not recommended for fish stocks that have high variation in growth between years and cohorts because of overlap in size distributions between age classes. However, the Department may use a length-frequency key to monitor for major changes in the size distribution of the stock, which, if detected, may signal the need for additional data collection and/or increased precaution in management. As an example, a high proportion of small fish in the commercial catch might suggest that the fishing gear is selecting too many young fish, before they have had an opportunity to spawn. The goal of the current tiered management approach is to target older age classes, age four and five. Conversely, a decline in the number of age six and older fish in the catch over time might suggest that mortality rates (due to fishing or natural mortality) are increasing.

7.5.2 Fishery-Independent Monitoring of Tier 2 Management Areas

In Tier 2 management areas, the Department monitors spawning behavior of the Herring stock. This helps ensure that harvest is not taking place on an un-monitored stock, and alerts Department biologists to situations that may require implementation of a zero-ton quota. The full spawn deposition survey protocol used historically (Section 6.1.2.1) is resource and staff intensive, and conducting this survey in reduced-capacity management areas fishing the precautionary Tier 1 quota is not necessary. Accordingly, under Tier 2, the Department can employ a Rapid Spawn Assessment Method (Section 6.2.1.1, Appendix P). This methodology can be used to monitor the number of spawns, spatial extent of spawns, and relative egg density per spawn in a given season. Together, these indicators provide a basis for detecting changes that may signal the need for additional data collection or management actions. The Rapid Spawn Assessment Method could be built into a collaborative research program to assist the Department in ensuring that all spawning events are sampled each season. For example, agency staff, fishermen, citizen scientists, or organizations could report the location of spawning events to Department staff. Assistance may also include collecting the spawn samples and recording the spatial extent of spawning (Section 6.2.1.2). Permit holders could also be incentivized to assist with monitoring to increase the likelihood of potential increased quota adjustments.

Should Herring permit holders request, through a DHAC meeting, a quota increase from the precautionary quota carried over from Tier 1, Department biologists may implement a full spawn deposition survey during a single season in order to produce an estimate of SSB for that season. That SSB estimate would be used to inform any potential quota increase (Section 7.5.3)

7.5.3 Adjusting Quotas in Tier 2 Management Areas

A Tier 2 management area allows the commercial fleet to fish a precautionary quota set at 1.5 to 3% of the average historical SSB, or 50% of historical catches for that area. If spawn deposition surveys are conducted to produce an estimate of SSB, the Department's Director may increase the quota for a given management area up to either 4% of the average historical SSB for Tomales and Humboldt Bay management areas, or up to 60% of the historical average catch for Crescent City Harbor. For San Francisco Bay, the Tier 2 adjustment will be based on the HCR. When selecting a quota for each management area, the Department will consider any available recent and historical data on spawning stock abundance, fishery-dependent information on the size/age structure, and the catch history. Conversely, under a Tier 2 monitoring protocol, the quota shall be reduced to zero as a rebuilding provision in years where either the employed Rapid Spawn Assessment indicates very poor spawning behavior, or spawn deposition survey-derived SSB estimates indicate an SSB that is overfished or otherwise depressed. For San Francisco Bay, the stock is considered overfished or otherwise depressed at SSB estimates below the 15,000-ton cutoff established by the HCR (see Section 7.7.1). For Tomales Bay and Humboldt Bay, the stock is considered overfished or otherwise depressed at stock sizes that are less than 20% of the long-term average biomass (including historical and contemporary SSB estimates) for each respective management area. For Crescent City Harbor, the stock is considered overfished or otherwise depressed at SSB estimates less than 66 tons, which is approximately three times the average historical catch in that management area.

7.6 Tier 3 Management Areas

If recommendations through a DHAC meeting for quota increases are requested beyond those allowed under Tier 2, and the Department determines it appropriate, permit areas may be managed under a Tier 3 monitoring protocol. A Tier 3 management area utilizes a HCR, informed by both fishery-dependent and fishery-independent monitoring protocols that are implemented annually (Sections 6.1.1 and 6.1.2), to set quotas. The primary indicator of stock status is produced by spawn deposition surveys, from which the total SSB for a season is calculated. Additional monitoring includes sampling the commercial catch to determine age, weight, and length composition, as well as conducting research trawls to determine the age, weight, length, and sex composition of each observed spawning wave. At the time of FMP development, San Francisco Bay is the only area that is considered a Tier 3 management area. In addition, the San Francisco Bay management area uses an annual index of YOY abundance produced with Department’s Bay Study Program’s midwater trawl survey data.

Setting quotas in Tier 3 management areas requires accurate estimation of the total SSB order to set a quota that will achieve the desired harvest rate. Historically, in San Francisco Bay, the Department has used the observed SSB and/or hydro-acoustic surveys from the previous season to set the quota for the upcoming season. In-season estimates are not available due to the long spawning duration, typically November-March. Given the wide variation in spawn timing and individual spawning wave size, in-season estimates to inform a commercial quota are not practical. This section describes the current empirical method, as well as a new method that uses a predictive model to estimate the next year's SSB for the San Francisco Bay management area.

7.6.1 Empirical Surveys to Estimate SSB

In San Francisco Bay, quotas for next season have been set based on a percentage of the most recent season's SSB. This is the intended harvest percentage, or target harvest rate, for the upcoming season. The intent is to achieve an actual exploitation rate of a given year's SSB that closely approximates the intended harvest percentage. An exploitation rate that closely matches the intended harvest percentage is more achievable when the biomass in the coming season is similar to the biomass observed last season. When this method was first developed in San Francisco Bay, Herring stock sizes were more stable from year to year. However, since the early 1990s the Herring SSB has exhibited higher inter-annual variability. Differences in the SSB from year to year can lead to higher than intended exploitation rates when stock sizes decline sharply between years. Despite the increase in variability of estimated stock size from year to year, determining SSB from observed spawn deposition has been used successfully since the beginning of the fishery, and as the primary quota-setting tool since the early 2000s, when hydro-acoustic surveys were discontinued, as described in Section 6.1.2.3. The spawn deposition method is considered the primary estimation method for quota setting in San Francisco Bay.

7.6.2 Multi-Indicator Predictive Model to Estimate SSB

Prior to FMP development, ecological indicators had been assessed each season and presented as part of annual season summaries to the DHAC and the public in support of Department management recommendations for the upcoming season, as well as to provide context for the SSB estimate. These had not been used, however, to quantitatively predict the SSB to set fishery quotas. As part of the FMP development process, information on correlations between biological indicators of Herring stock health and environmental indicators were used to develop a predictive model to estimate the coming year's SSB (Sydeman and others, 2018) (Section 3.4.1, Appendix E). This model includes three indicators:

1) SSB_{yr-1} – the observed spawn deposition from the previous season
2) YOY_{yr-3} – the CPUE of YOY Herring from April to October three years prior to the upcoming season
3) $SST_{Jul-Sep}$ – The average SST between July and September prior to the upcoming season

Relative to a simple regression that uses SSB_{yr-1} to predict the upcoming season's SSB, the above-described model explains more variability and reduces predictive error by a large margin (Sydeman and others, 2018) (Appendix E). Mechanistically this model supports what is known about Herring stocks. The majority of Herring in the San Francisco stock are thought to mature between ages two and three, and considered fully recruited to the spawning stock by age three. Including YOY_{yr-3}, in addition to SSB_{yr-1}, as an explanatory variable in the model improves the accuracy of the output estimate, because the spawning stock that comes into the bay to spawn is a function of both the survivors from the previous year and the recruiting year class. Additionally, it has long been hypothesized that, in some years, not all Herring come into the bay to spawn, possibly due to environmental cues. The summer and fall SSTs were found to be negatively correlated with the observed spawning biomass later that same winter, suggesting that warmer temperatures may indicate poor conditions for adult Herring, resulting in behavior that results in fewer spawners during the spawning season. The synthesis of different environmental and ecosystem data into a multivariate forecasting equation may promote proactive, rather than reactive, management, and foster an interdisciplinary approach to ecosystem-based fisheries management.

7.6.2.1 Steps to Estimate Biomass Using Predictive Model

This section describes the steps necessary to estimate SSB using the predictive model. All necessary data may be available by the end of September each year, and prior to the beginning of the fishing season, which begins in December.

Step 1: Gather and process the necessary indicators

1. SSB_{yr-1} — the total spawn deposition from the previous November-March is summed and converted to metric kilotons.
2. YOY_{yr-3} — YOY abundance data are available from the Department's Bay Study Program, which collects abundance data on pelagic fish using midwater trawls throughout San Francisco Bay at monthly intervals for 52 stations (Section 6.1.2.4); this analysis is based on the original 35 stations that have been sampled since 1980, including those in the central San Francisco Bay region where Herring are common (Baxter and others, 1999). Data on the age zero, one, and two Herring observed in the trawls are routinely provided to Herring managers each year. To summarize YOY_{yr-3} abundance, calculate the mean catch CPUE for three years prior (for example, to make a prediction for the fishing season beginning in 2020, use YOY data from 2017). First select the appropriate stations using only Series = 1 (representing the original 35 stations), and calculate CPUE for each station using the following equation:

$$CPUE = \left(\frac{PACHER_{Age0}}{tow\ volume}\right) * 10{,}000 \quad [1]$$

where $PACHER_{Age0}$ represents the number of age zero Herring caught in each tow and is scaled by the tow volume data. Next sum the CPUE data for April-October (months 4-10). Finally, average the summed monthly data.

3. $SST_{Jul\text{-}Sep}$ — The SST for July through September is available from offshore buoy N26 at station 46026 provided by the National Data Buoy Center and NOAA[6]. For each month, average the temperature data available, then subtract the mean temperature from each month (based on years 1985-15: July = 13.16°C (55°F), August = 13.97°C (57°F), September = 14.24 °C (58°F)) to calculate the temperature anomaly for each month. Finally, average the anomaly across the three months (July-September).

Step 2: Apply the forecasting model

Insert the formatted indicators into the following equation to calculate the coming year's SSB:

$$SSB_{Next} = 0.2803 * SSB_{Yr-1} + 0.019026 * YOY_{Yr-3} - 7.2582 * SST_{Jul-Sep} + 4.092 \quad [2]$$

Step 3. Model Validation

Model validation should be conducted every year after the spawning season is complete to verify model prediction skill. To validate that the modeled SSB is still performing within the range of deviation described by the regression equation (69%), comparison of predicted and observed SSB (December-March) estimates is required. Calculate the percent deviation using the predicted SSB for the season that has just passed using the following equation:

$$Perc\ Dev = \frac{Observed\ SSB - Predicted\ SSB}{Observed\ SSB} * 100 \quad [3]$$

If the model prediction skill deviates from the mean value (>69%) in one year, no management response is required. If skill deviates by greater than 69% for two sequential years, this should be considered a warning. If it deviates for more than two sequential years, the model should be revaluated and checked for continuing veracity. The model prediction skill should also not stay consistently above or below the mean. In either of these cases, the spawn deposition surveys will be used to estimate biomass and set quotas. Regardless of annual model prediction skill, every five years the Department should test for continuing significance of predictor variables (i.e., the independent variables) in the forecasting model. If terms lose significance or model prediction skill decreases significantly, the Department should consider revision of the

[6] http://www.ndbc.noaa.gov/station_history.php?station=46026

forecasting model to verify that the relationships between SSB, YOY abundance, and SST still exist.

7.6.3 Determining Which Method to Use in Estimating SSB in San Francisco Bay

The spawn deposition surveys have been and remain the default method for estimating the SSB in San Francisco Bay to set quotas. While the predictive model provides a promising avenue for incorporating additional indicators into Herring management, as well as for improving predictive accuracy, the model's use depends on the availability of required data and the model's continued predictive skill (see Section 7.6.2.1, Appendis E). When these two requirements are met, the Department may decide to use the predictive model in yearly quota setting.

7.7 Harvest Control Rule Framework for San Francisco Bay

Quotas in Tier 3 management areas are set using a HCR to ensure that quotas are appropriate given the current SSB, that the biomass is above the cutoff, and that intended harvest percentages are no more than 10%. Additionally, the status of environmental and ecosystem indicators (Section 7.7.2) will be examined to monitor current ecosystem conditions, and the Department will include information on these indicators and their interpretation in periodic season reports. Each step is described in detail below.

7.7.1 Using the Harvest Control Rule to Determine the Quota

A HCR has been developed to set quotas based on an annual San Francisco Bay Herring SSB input, derived either from the above-described predictive model (Section 7.6.2) or the previous season's estimate from empirical surveys (Section 7.6.1, Figure 7-2). The HCR was developed in consultation with Department staff and stakeholders, and was tested using MSE to understand its performance under various uncertainty scenarios, including climate change scenarios. It was shown to be robust to the scenarios tested, which included a number of reduced productivity situations (Appendix M).

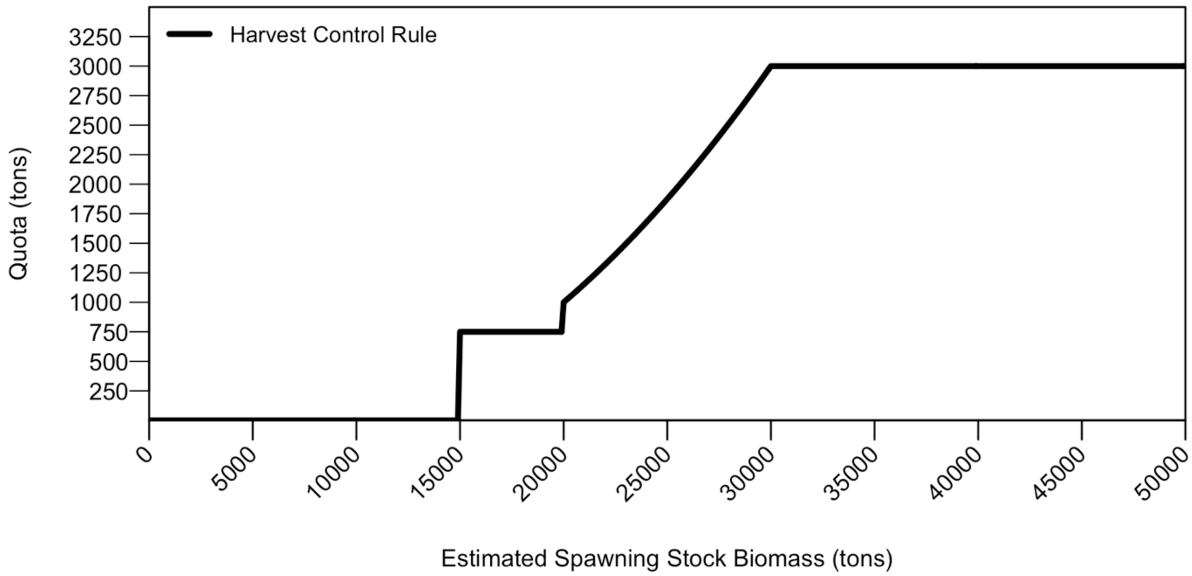

Figure 7-2. Harvest Control Rule describing the relationship between estimated SSB and unadjusted quota for subsequent season of the San Francisco Bay Herring commercial fishery.

The quota for each season is calculated by inserting the estimated SSB into Equation 4 (also described in Table 7-1).

$$Quota = \begin{cases} 0 & if\ SSB < 15{,}000t \\ 750 & if\ 15000t \leq SSB < 20{,}000t \\ SSB * (SSB * 0.000005 - 0.05) & if\ 20{,}000t \leq SSB < 30{,}000t \\ 3{,}000 & if\ SSB \geq 30{,}0000t \end{cases} \quad [4]$$

Table 7-1. Prescribed quota (and associated harvest rate) in tons for each estimated SSB in San Francisco Bay.

Spawning Stock Biomass (t)	Harvest Percentages	Quota (t)	Description
<15,000	--	0	No harvest below 15,000t cutoff
15,000	5.00%	750	Low fixed quota to maintain limited fishing opportunity for the commercial fleet
16,000	4.69%	750	
17,000	4.41%	750	
18,000	4.17%	750	
19,000	3.95%	750	
20,000	5.00%	1,000	Harvest rate ramps up from 5% to 10% as stock size increases
21,000	5.50%	1,155	
22,000	6.00%	1,320	
23,000	6.50%	1,495	
24,000	7.00%	1,680	
25,000	7.50%	1,875	
26,000	8.00%	2,080	
27,000	8.50%	2,295	

28,000	9.00%	2,520	
29,000	9.50%	2,755	
30,000	10.00%	3,000	
>30,000	--	3000	Unadjusted quota limit fixed at 3,000t

The HCR includes a cutoff at 15,000 tons (13,600 metric tons), below which no fishing will occur and the quota for the coming season will be zero. The selection of this cutoff was based on a number of different factors. Simulation analysis suggested that continued harvest at low stock sizes (0 – 10,000 tons, depending on the productivity assumptions) delayed the recovery of the stock to healthy levels. Cutoffs above 10,000 tons (9,100 metric tons) had minimal additional benefits to the Herring stock, which diminished quickly as cutoffs increased. However, cutoffs have been suggested as a way to consider forage needs at low stock sizes, and reduce competition between predators and fishermen (Cury and others, 2011; Pikitch and others, 2012). While there is minimal information available to determine what level of cutoff is required to meet the forage needs of Herring predators, this HCR incorporates an additional 5,000 tons (4,500 metric tons) into the 10,000-ton base cutoff level for a total cutoff of 15,000 tons. This higher cutoff provides an additional level of precaution given the lack of information on predator dependency on Herring. The 15,000-ton cutoff was agreed to by fishery stakeholders and may also help to buffer against additional uncertainty in future climate change scenarios.

If the SSB is between 15,000 and 20,000 tons (13,600 and 18,100 metric tons), the quota for the coming season will be set at 750 tons (680 metric tons). This represents an agreement among industry and conservation stakeholders to reduce the number of years with a zero quota, which can have long-lasting implications on market access, while also minimizing the impact on the forage base when stocks are below 20,000 tons. For SSBs from 20,000 tons to 30,000 tons (18,100 to 27,200 metric tons), the harvest rate increases linearly from 5 to 10%. Table 7-1 shows the intended harvest percentages and quotas associated with SSB estimates in this range. MSE testing found that by ramping the harvest up from 5 to 10% across this range rather than starting with a higher harvest rate had slightly higher performance in terms of long-term stock health. For SSBs of 30,000 tons and above, the quota will be capped at 3,000 tons (2,722 metric tons), prior to any ecosystem-based quota adjustment. This cap was developed in consultation with fishing industry representatives and reflects the anticipated capacity of the fleet. This cap may also be beneficial to predator-prey relationships, which are likely to grow in significance during times when the Herring population increases.

7.7.2 Incorporating Ecosystem Considerations into Herring Management

One of the primary goals of this FMP was to formalize the precautionary management approach that Department has been using since 2005. The

Department has long considered SSB estimates and annual quota recommendations within the context of available ecosystem indicators, but quota setting procedures did not include a protocol for interpreting the status of these indicators. A secondary goal was to progressively incorporate ecosystem based EFI in compliance with the Commission's forage species policy. In this FMP, ecosystem considerations are incorporated in multiple ways.

The HCR, which includes a precautionary harvest rate, biomass cutoff, and quota cap, is more conservative than the harvest strategies currently used in other Herring stocks (Fisheries and Oceans Canada, 2016), and is designed to ensure that fishery needs do not supersede the forage needs of mid-trophic CCE predators. In addition, the predictive model to estimate SSB improves the Department's ability to proactively manage the Herring stock as it responds to environmental and ecological conditions. This approach helps to ensure that precautionary harvest rates are achieved, and that harvest is reduced or eliminated in low productivity years to meet ecosystem needs. In addition, ecosystem conditions are further incorporated into Herring management in two ways. First, as was the case prior to implementation this FMP, indicators of ecosystem productivity are considered annually alongside SSB estimation and quota recommendation, and this consideration is described periodically in status reports, with a particular emphasis on those indicators that have been linked to Herring productivity (Section 7.7.2.1). Second, the quota may be adjusted as necessary due to concerns about key predators or regional forage conditions using a decision tree (Sections 7.7.2.2 and 7.2.2.3). Together, the indicators identified in each of these tools provide a holistic view of the health and productivity of the system, ensuring that decisions about the Herring stock are placed in the context of the larger ecosystem.

7.7.2.1 Enhanced Status Report

Indicators of ecosystem health and Herring productivity are described in Table 7-2, along with their ecological interpretation and what changes in these indicators may mean for Herring management. To monitor changes in ecosystem health and to place Herring management decisions in an ecosystem context, Department staff should describe ecosystem status at periodic intervals in the Enhanced Status Report. This report will describe the status of each ecosystem indicator in Table 7-2 and the anticipated effect on the productivity of the Herring stock and the central CCE as a whole, currently and in the coming years. Indicators should be considered individually as well as in concert. It is hoped that, through continued monitoring of these indices as well as future research, this approach will provide a basis for use of these indicators in fishery management and inform future efforts.

Table 7-2 includes indicators on oceanographic and terrestrial conditions, and Herring productivity. These are designed to assist managers in understanding current conditions for the Herring population, as well as how the size of the SSB might change in the coming years.

Table 7-2. Matrix of EFI for assessing ecosystem conditions when setting quotas for the Herring fishery in San Francisco Bay.

Data	Interpretation	Implications for Herring Management
Oceanographic Indices		
Pacific Decadal Oscillation (PDO)	Positive PDOs are associated with warmer waters and lower productivity in the CCE, while negative PDOs are associated with cooler waters and higher productivity.	PDO fluctuations affect the primary producers that are food for Herring, so periods of positive PDOs may negatively impact Herring SSB.
Oceanic Niño Index (ONI)	Positive ONI indicates El Niño conditions (warmer and wetter), while negative ONI indicates La Niña conditions (cooler and drier).	El Niño events negatively impact productivity in the CCE, which can indirectly affect food availability for Herring. El Niño events may also reduce larval or juvenile Herring survival, reducing recruitment and impacting Herring year class structure (Sydeman and others, 2018).
Cumulative Upwelling Index	Upwelling results in the transport of cool, high–salinity, nutrient–rich water onshore. Delayed coastal upwelling (known as the Spring Transition) severely depresses the productivity at the base of the CCE.	Strong upwelling provides nutrient-rich water that positively impacts primary producers, which indirectly affects food availability for Herring. Years with weak upwelling may correspond to lower SSB estimates.
SST Anomaly	High SST is associated with lower productivity, while low SST is associated with higher productivity for species such Herring.	A lower SSB might be expected in years where SST anomaly is above average due to lower food availability for cold water species in the CCE.
Buoy N26 SST	Summer SST (Jul-Sep) is negatively correlated with observed spawning deposition in the following season. Warmer waters may mean that conditions for adult Herring are poor, and either survival or spawning may be lower.	Warmer waters may reduce spawning returns in the coming season, while cooler waters may indicate good spawning conditions.
Terrestrial Environmental Indices		
Outflow metric (Sacramento/ San Juaquin delta)	Outflow is affected by precipitation, snow melt, and water diversions, and affects the salinity gradient in the bay. Herring may use freshwater output as an indicator of where to find estuaries with suitable salinity conditions for spawning.	Very high outflow may increase turbidity and lower salinity, which may result in poor spawning conditions for Herring. Very low outflow may result in salinities that are higher than optimal for larval and juvenile survival. Moderate outflow may provide the best conditions for Herring.

Snow Water Equivalent (SWE)	The SWE is a metric of the water stored in the snow pack. Snow melt influences salinity in the Bay during the dry season (summer/fall).	Low SWE may have negative consequences for juvenile Herring survival during the summer months (but see Kimmerer (2002a) for a caveat here).
Biological Indices		
Southern Copepod Index	Higher index of Southern Copepod species usually accompanies periods of lower productivity in the CCE	Southern Copepods are less lipid rich and provide a less desirable food source for forage species in the CCE such as Herring, so a higher index here indicates less favorable conditions.
Northern Copepod Index	Higher index of Northern Copepod species usually accompanies periods of higher productivity in the CCE.	Northern Copepods are more lipid rich and nutrient dense, providing better food for Herring, so a higher index for this species indicates more favorable conditions.
Herring YOY Index	This index measures the number of juvenile Herring in San Francisco Bay during the late spring and summer months. These Herring will leave the bay in the last summer and fall to join pelagic Herring schools.	The YOY index has been shown to be positively correlated with the winter SSB three years later. Herring mature between ages two and three and recruit to the fishery during that time, so a high YOY suggests a larger SSB in three years, and a low YOY suggests a smaller SSB in three years.
Percentage of Age Two and Three Herring in the Catch	The gill net fishery targets primarily age 4, 5, and 6 yr old fish. Between 2005 and 2018, the number of age three or younger fish has been under 20% every year. Tracking the age composition of the catch can be an informative indicator of Herring productivity and survival.	If the percentage of age three- fish is higher than average it may signal a strong recruitment year and larger than average SSB in the next two or three years. However, if the fishery begins to consistently have high numbers of young fish in the catch the gear selectivity should be examined.
Percentage of Age Six and Older Herring in the Catch	The presence of older Herring (age six and older) in the catch suggests low mortality rates that allow some individuals to survive to older ages. These fish tend to be larger and may spawn earlier in the season.	If the percentage of age six and older fish decreases, this suggests that mortality (either fishing or natural mortality) may be higher, preventing survival to old age. If the percentage of age six and older fish is higher than average this may signal a period of decreased recruitment to the fishery.

7.7.2.2 Decision Tree to Adjust the Quota Based on Predator-Prey Conditions

The peer review of this FMP concluded that the HCR described in Section 7.7.1 is likely to ensure that the resource needs of the commercial Herring fishery do not negatively affect Herring's role as forage for mid-trophic predators in the central CCE (Appendix O). However, one of the goals of this FMP was to develop a process to explicitly consider both regional predator population conditions and regional forage availability in quota setting decisions. Given the uncertainty about the needs of predators, as well as concern about recent and potential future changes in the composition of the CCE, additional precaution during years when forage is low may be warranted.

Based on the available information on observed diet composition of predators in the area in and around San Francisco Bay (Chapter 3), a suite of indicators was selected to track the health of key predator populations as well as regional forage availability. To assist Department staff in determining whether quota adjustments may be necessary, and if so, how those adjustments should be applied, a decision tree process was developed (Table 7-3).

Once the SBB is estimated (Section 7.6) and the preliminary quota is determined, Department staff will follow the decision tree to determine whether any quota adjustment should be considered. The first step in the decision tree relates to the size of the estimated Herring biomass, because a quota reduction based on ecosystem considerations is only warranted if the stock is between 20,000 and 40,000 tons. Once the SSB is larger than 40,000 tons, the stock is at 40-50% of the estimated average unfished biomass (Appendices B and M) and is thus considered able to meet forage needs of predators without additional quota reductions. However, at an SSB below 40,000 tons there may be a benefit to reducing harvest if ecosystem conditions suggest that forage conditions in the central CCE are unusually poor. Alternatively, if forage conditions and predator populations are relatively large, the quota may be increased to allow fishermen to take advantage of good conditions when SSB is greater than 20,000 tons. When the stock is between 15,000 and 20,000 tons, a quota of 750 tons is in place to preserve the ability of fishermen to access the fishery while minimizing potential ecological impacts of harvest. Because a lower quota is economically unfeasible, no quota adjustments based on ecosystem conditions are warranted when the SSB is in this range except under emergency conditions, when the quota may be set to zero. When the SSB estimate is below 15,000 tons, the quota is zero.

The next set of criteria (questions 2 through 5; Table 7-3) assess unusually poor conditions in predator populations that may be related to limited forage availability. Incorporating indicators of predator health into management decisions is challenging. Predators are often opportunistic, and tend to eat a wide variety of species depending on availability. While a number of predators are known to eat Herring in the CCE, a comprehensive meta-analysis of all known dietary studies found that there is little information available to link San Francisco Herring to specific predator populations (Szoboszlai and others, 2015). This does not mean that Herring aren't an important dietary source for predators, but few studies are conducted in winter, and so there are few data available during the season when Herring are most abundant in the area in and around San Francisco Bay. A suite of predators that are known to eat Herring in the area (Section 3.3.2) have been included in the decision tree. While it is expected that predator populations will experience natural fluctuations, unusual mass mortality events should be investigated to determine whether the cause is linked to food availability. If so, this may provide an indication of poor forage conditions for local predators.

NOAA tracks marine mammal mortality events in the United States[7], and the United States Geological Survey tracks mass mortality events for terrestrial species[8]. This information should be used by Department staff to determine whether there is a mortality event currently in progress for any of the species listed in question 2. If there is currently no mortality event in progress, Department staff may proceed to question 5. If there is an event affecting one of the indicator predator populations, the information provided on these websites should also be used to assess the location of the mortality event (question 3). It may be difficult to assess the primary location of an ongoing mass mortality event, especially in a species that is migratory or has a very large home range. Department staff will evaluate the best information available at the time when quotas are being set and will decide whether a high proportion of observed mortalities are occurring in the central CCE. Department staff will also need to determine whether the mortality event is caused by a lack of forage (question 4), which may manifest itself with signs of emaciation or starvation. It should be noted that in the past, some mortality events have been inconclusive or caused by non-forage issues, including infectious diseases or exposure to biotoxins such as domoic acid. These events would not warrant a reduction in the quota because they are not caused by a lack of forage in the system. It may take some time to determine the cause of a predator mortality event. In the event of a mortality event where the cause is yet undetermined, no quota reduction is warranted. This is because the HCR is already precautionary, and without direct evidence of forage-related conditions, quota reductions would not be warranted. Should the criteria in questions 2, 3, and 4 all be met, the decision tree directs Department staff to consider a quota reduction (discussed in Section 7.7.2.3).

Chinook Salmon have been directly linked to San Francisco Bay Herring through dietary studies (Merkel, 1957; Thayer and others, 2014). Question 5 compares the forecasted oceanic abundance of the Sacramento River fall-run Chinook Salmon with the upper range for the escapement target that has been set by the PFMC. If the forecasted oceanic abundance is below 180,000 fish, the decision tree recommends considering a quota reduction. This forecast is available in the spring, prior to the time when quotas are set for the Herring fishery. This salmon population is intensively managed, and pre-fishery ocean abundance forecasts are primarily driven by ecological conditions, as fishing is yet to occur (PFMC, 2019). There is no immediate way to know whether low oceanic abundance is specifically due to a lack of forage, but given the direct

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[7] https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

[8] https://www.nwhc.usgs.gov/whispers/searchForm/index

connections between Chinook Salmon and San Francisco Bay Herring that have been observed, should the pre-season ocean abundance salmon forecast fall below the upper end of the escapement target range, care should be taken to consider adequate Herring for forage when population levels are extremely low.

Questions 6-10 aid Department staff in assessing regional forage availability in the central CCE. If the forage indicators suggest that prey conditions in the central CCE are unusually poor (as defined in the decision tree) a reduction in quota may be necessary. Conversely, unusually good conditions might suggest that an increase in quota is warranted. The regional forage indicators identified in questions 6, 7, and 8 rely on variability indices provided by the California Current Integrated Ecosystem Assessment (CCIEA) project, which synthesizes data for the central CCE region (with most data coming from the region around San Francisco Bay). The central CCE forage community includes a diverse array of species and life history stages, each varying in behavior, energy content, and availability to predators, and the relationships between the availability of each type of forage and the Herring stock are not well understood. For this reason, multiple indices are used to provide a holistic look at forage conditions. Krill are important forage for Herring and many other species, and unusually low krill abundances may suggest the potential for reduced productivity, both for the Herring stock and for the entire central CCE. Pacific Sardines and Northern Anchovy are perhaps the most important central CCE prey species because of their high lipid content. The regional indices of relative forage availability of other important forage species such as Market Squid and YOY groundfish such as Pacific Hake, rockfish, and Sanddabs are also tracked (Harvey and others 2017). While these indicators reflect prey conditions during the summer and may represent a spatial distribution that is further offshore than Herring tend to range, these indicators offer the best available science describing the general forage availability within the central CCE.

Table 7-3. Decision tree to assess predator-prey conditions in the CCE.

Herring	1. Is the biomass estimate greater than 20,000 tons?	No	Do not adjust quota.
		Yes	Proceed to 2.
Predators	2. Is there an unusual mortality event in progress in California for one of the following species: Common Murre, Rhinoceros Auklet, Harbor Seals, or California Sea Lions?	No	Proceed to 5.
		Yes	Proceed to 3.
	3. Is the mortality event occurring in Central California (e.g., Sonoma, Marin, San Francisco, San Mateo, Santa Cruz, Monterey counties)?	No	Proceed to 5.
		Yes	Proceed to 4.
	4. Is the cause of the mortality event attributed to or exacerbated by lack of forage, and the Herring biomass estimate is < 40,000 tons?	No	Proceed to 5.
		Yes	Consider reducing quota.
	5. Is the forecasted ocean abundance of Sacramento River fall-run Chinook Salmon < 180,000, and the Herring biomass estimate < 40,000 tons?	No	Proceed to 6.
		Yes	Consider reducing quota.
Regional Forage	6. Calculate whether YOY Hake, YOY Rockfish, YOY Sanddab, Market Squid, and krill in the central CCE are more than 1 standard deviation below the long term mean. These indicators are classified as "unusually low".		Proceed to 7.
	7. Calculate whether central CCE regional indices of relative forage availability for Adult Pacific Sardine and Adult Northern Anchovy are below 50% of the long term mean. These indicators are classified as "unusually low".		Proceed to 8.
	8. Calculate the number of forage indicators that are more than 1 standard deviation above the long term mean. These indicators are classified as "unusually high".		Proceed to 9.
	9. Are there currently > 5 forage indicators that are unusually low, and the Herring biomass is < 40,000 tons?	No	Proceed to 10.
		Yes	Consider reducing quota.
	10. Are there currently > 3 forage indicators that are unusually high, and the answer to lines 2, 5, and 6 is no?	No	Do not adjust quota.
		Yes	Consider increasing quota.

7.7.2.3 Adjusting the Quota Based on Ecosystem Considerations

Should one or more of the criteria in the decision tree recommend that the Department consider reducing the quota, the target harvest rate may be increased by up to 1% (Figure 7-3). If applied to an SSB of 20,000 tons, where the HCR recommends a 5% target harvest rate, resulting in a quota of 1,000 tons, the harvest rate would be adjusted down to 4%, resulting in a quota of 800 tons. At a SSB of 25,000 tons where the HCR recommends a 7.5% target harvest rate, resulting in a quota of 1,875 tons, the target harvest rate would be adjusted down to 6.5%, resulting in a quota of 1,625 tons. At SSBs between 30,000 and 40,000 tons, the quota would be reduced to 2,700 tons. Conversely, if an increase is warranted, the target harvest rate may be increased by up to 1% (Figure 7-3). At a SSB of 20,000 tons, the target harvest rate would be adjusted up to 6%, resulting in a quota of 1,200 tons. At a SSB of 25,000 tons, the target harvest rate would be increased from 7.5% to 8.5%, resulting in a quota of 2,125 tons. However, because the target harvest rate is capped at 10%, per an agreement from the SC, increases to the target harvest rate due to ecosystem considerations at estimated SSBs between 28,000 and 32,000 tons are limited. At 33,000 tons or greater SSB, the maximum possible adjusted quota is 3,300 tons.

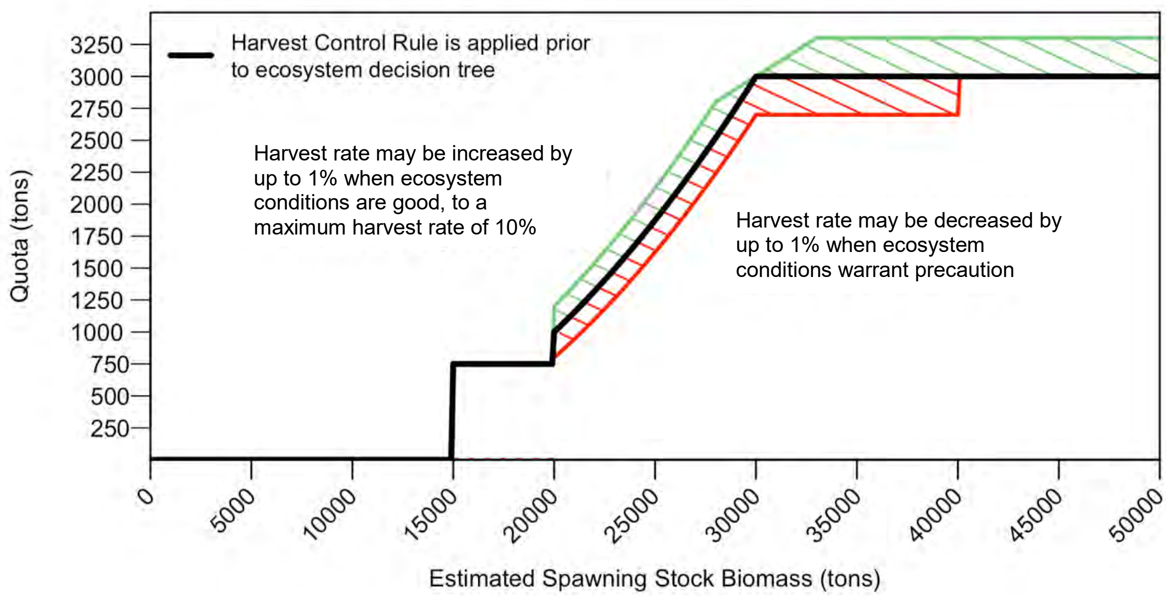

Figure 7-3. Possible range of quotas under the harvest control framework after the ecosystem decision tree is applied.

7.7.3 Application of Management Framework

While there is a desire to have a clearly described and transparent mechanism for setting the quota each year (i.e., the HCR framework described in Sections 7.7.1 and 7.7.2), there is also a need to maintain the ability of Department staff to assess and, if necessary, respond to unforeseen conditions as they arise. This balance between having both a pre-determined process, as well as bounded flexibility in yearly management decisions, is a key component of this FMP, because it is impossible to plan for every possible future scenario that may arise in a complex ecological system.

The Department will follow the previously described quota setting framework but will reserve a level of discretion given the uncertainty related to data availability, as well as resource and staff constraints. Quotas must be announced each year by November 1 to allow fishermen the time to prepare for the season, and quotas must be set using the best available information. The management strategy described in this FMP relies on a number of data that are collected by other projects within the Department (YOY Herring index, forecasted oceanic abundance for Chinook Salmon) as well as other agencies (predator mortality events, regional forage indicators, environmental conditions). It is possible that in some years one or more data streams may be unavailable due to a disruption in sampling. Under that scenario, the Department will apply the HCR framework based on the best available information. Should any of these data become permanently unavailable, the Department will need to develop an alternative method for incorporating ecosystem indicators into quota decisions based on what is available.

Ecosystem-based fishery management is an emerging science and new indicators, as well as methods for incorporating them into fisheries management, are continually in development. In recognition of this, the suite of indicators used to assess ecosystem conditions (Table 7-2) and evaluate the need for ecosystem-based quota adjustments (Table 7-3) may be updated by the Department as needed to reflect the best available science (Section 9.1). As an example, the forage indicators used in the decision tree reflect what is known about forage availability in the central CCE, but may not be the best metric to describe coastal forage, or accurately reflect alternative forage for Herring predators, which is largely unknown due to the limited number of diet studies specific to the winter months. As additional data become available and the science evolves, there may be a better understanding of the linkages between ecological indicators, the Herring stock, and the wider CCE, and Department staff may then update the indicators used in Tables 7-2 and 7-3. When altering or adding indicators it is important to focus on those that overlap geographically and temporally to the extent possible with California's Herring stocks.

The Department retains the discretion to act to protect the Herring resource beyond what is specified in this management strategy. Department staff may set a zero quota or otherwise enact an emergency quota in the event of extreme environmental conditions or disasters, such as in the case of an oil spill or unprecedented environmental or ecological conditions. In this case, the stock should be closely monitored for the season, and conditions should be reevaluated prior to the next season. Closing the fishery for an entire season has economic impacts for the commercial fleet, and should only be considered under poor ecological conditions that would be detrimental to the stock and its ability to recover.

7.8 Management Measures and their Anticipated Impact on the Stock

While quotas are the primary basis for ensuring sustainability in Herring stocks, additional management measures are necessary to provide safeguards for the stock, as well as to mitigate conflicts between user groups to the extent possible. This section describes those additional management measures.

7.8.1 Restrictions on Catch

This FMP requires that commercial catch limits, in the form of annual quotas, be set for each of the four management areas where Herring fishing is allowed. Quotas in the three northern management areas will be set at a precautionary level based on available historical spawning biomass data and/or landings history (Section 7.4). Quotas in the San Francisco Bay management area will be set in accordance with the HCR framework described in the sections above. This framework ensures that: a) quotas are set as a percentage of the total estimated spawning stock for fished stocks that are intensively monitored, b) target harvest rates are low (or zero) when Herring stock sizes are small in order to reduce impacts to the sustainability of the stock and the ecosystem as whole, and c) current forage conditions in the central CCE are tracked and described to provide environmental context. This management framework is comprehensive, adaptive, and based on the best available science.

The HCR framework proposed in this FMP meets the requirements of the MLMA, which state that FMPs must specify criteria for identifying when the stock is overfished, include measures to end or prevent overfishing, and provide a mechanism for rebuilding in the shortest time period possible (FGC §7086). This is achieved by providing clear definitions of when the stock is in a depressed state (which may occur due to either overfishing or natural fluctuations) via the cutoff prescribed in the HCR. It also provides a clear rebuilding plan should the stock be depressed by reducing quotas to zero until the stock recovers to a level above the cutoff, and implements more precautionary target harvest rates at low stock sizes to promote stock growth. The harvest cap is designed to reduce the chance of overfishing.

7.8.1.1 Allocation of Quota between Sectors

In developing this FMP, it is necessary to determine how the quota should be allocated between fishing sectors. Previously, the quota for the HEOK fishery sector was subtracted from the overall gill net quota and transferred to the HEOK sector to reflect the permits that elected to fish using HEOK rather than gill net or round haul gear in that season. This quota in whole fish weight was then converted to the number of eggs that biomass of fish could produce to determine the HEOK product weight. By removing fish from the sac-roe sector and transferring them to the HEOK sector, the Department reduced fishing mortality of adult Herring, because the HEOK fishery removes eggs but does not remove adult fish. This FMP establishes that the gill net sector quota will be set based on the HCR framework described above, and the total HEOK sector quota will be set at a product weight equal to 1% of the total quantity of eggs produced by the most recent estimated SSB (Appendix N).

7.8.2 Effort Restrictions

7.8.2.1 San Francisco Bay

During the FMP development process, a comprehensive review of the permitting system in San Francisco Bay was undertaken. This was one of the primary goals of this FMP and was initiated by fishing industry representatives during annual DHAC meetings. The prior permitting system was originally developed for a much larger fleet, and the platoon system, experience points, restrictions on the number of permits that could be owned, and the dedicated Herring account are no longer necessary or useful given reduced effort and participation in the fishery. The FMP development process provided an opportunity to modernize the permitting system and conform to operational requirements for other fisheries in California.

This FMP establishes the permitting system as follows:

- Odd, Even, and DH gill net permits will be reassigned as Temporary permits. CH permits will be reassigned as two Temporary permits. A Temporary permit allows the permittee to fish one shackle (65 ftms) of gill net during every week of the season from a single vessel. Permittees can hold up to three Temporary permits and these permits are transferable (Section 4.7.2).
- holders of two Temporary permits will be consolidated to a single San Francisco Bay permit. A San Francisco Bay permit allows the holder to fish two nets, each one shackle (65 ftms) in length, during all weeks of the season from a single vessel. Conversion to a San Francisco Bay permit is permanent and these permits are transferable.
- permittees can own a maximum of one San Francisco Bay permit, or one Temporary permit and one San Francisco Bay permit.
- Temporary and San Francisco Bay permits will receive new permit numbers, but will be traceable to the permits/platoons from which they were converted.
- permits will be issued to one permittee each, and may no longer be held in partnership.
- Temporary Substitutes and Experience Points are no longer needed, because a permittee may have any licensed commercial fisherman serve in his or her place on the designated vessel and engage in fishing, provided the permit is aboard the vessel named on the permit(s) at all times during Herring fishing operations.
- HEOK-designated Odd, Even, and DH permits will be reassigned as stand-alone HEOK permits. HEOK-designated CH permits will be reassigned as one HEOK permit and one Temporary permit each. HEOK permits are transferable and royalty payments are eliminated.

- deadline for receipt or postmark of application for renewal of all Herring permits in all management areas, without penalty, is April 30 of each year.

Under the consolidation described in this FMP each vessel can fish two Temporary permits simultaneously or one San Francisco Bay permit. All Temporary permits that are not renewed will be held by the Department until they can be converted to San Francisco Bay permits and reissued once the number of permits drops below the long-term capacity goal described below. Under the authority of this FMP, permittees will have five years from the date of FMP adoption to convert all Temporary permits to San Francisco Bay permits. Once the five-year deadline is reached, all Temporary permits will become non-transferrable and non-renewable. No new San Francisco Bay permits will be issued after the consolidation deadline until the number of permits falls below 30 San Francisco Bay permits.

This FMP also establishes a long-term capacity goal of 30 vessels (or 30 San Francisco Bay permits), with a maximum of two nets per vessel, which will likely be achieved through attrition due to economic conditions in the fishery. With a 3,000-ton (2720 metric ton) unadjusted quota cap in the HCR framework, a fleet of 30 vessels could catch up to 100 tons (91 metric tons) of Herring on average per vessel, though there is no vessel-based allocation of the quota. This level of harvest should maintain the economic viability of the fleet in years where the quota is near the 10% target harvest rate cap. Additionally, the HCR allows a small quota to be available to sustain a reduced fleet in years were SSB is between 15,000 and 20,000 tons (13,600 and 18,100 metric tons).

7.8.2.2 Tomales Bay

Under this FMP the permitting system will remain the same in Tomales Bay (Section 5.3.2), with the only changes being the maximum number of permits issued in this management area and permit application deadline. At the time of FMP development, the maximum number of permits allowed in Tomales Bay was 35. This FMP reduces that number via attrition to 15, (i.e. no new permits issued until the total number of Tomales Bay permits falls below 15). Should conditions change in the future, Department staff may find it necessary to adjust the permit capacity in accordance with the needs of the fleet and the level of catch the resource can support in this management area.

7.8.2.3 Humboldt and Crescent City

Under this FMP there are no proposed changes to the permitting system in the Humboldt Bay and Crescent City Harbor management areas except permit application deadline (Section 5.3.2). The number of permits in these areas specify a permit capacity of four permits. Should conditions change in the future, Department staff may find it necessary to adjust the permit capacity in accordance with the needs of the fleet and the level of catch the resource can support in these management areas.

7.8.3 Gear

At the time of FMP development, the gill net mesh size for San Francisco and Tomales Bays was set at 2-in (50 mm) and the minimum gill net mesh size for Humboldt Bay and Crescent City Harbor management areas was 2.25-in (57 mm). When mesh size for San Francisco and Tomales Bays was reduced in 2005 there was a concern that the reduction from 2.125-in (54 mm) (Section 5.4.3) would lead to a reduction in the size and age of the commercial catch. However, the proportion of fish age two and three in the commercial catch has remained at less than 15% since that time, except during a large recruitment event in 2010-11 and 2011-12, and the catch has primarily consisted of age four and older Herring (Figure 5-2). This is consistent with the Department's goal of ensuring that all Herring are able to spawn prior to becoming vulnerable to the fishery. The maximum mesh size for all management areas is 2.5-in (63.5 mm). No changes to the mesh size used in the gill net fleet are recommended at this time. However, emerging research suggests that selective harvest, in which certain size or age classes are caught at a higher proportion than they naturally occur in the population, may have adverse ecological effects (Garcia and others, 2012), and evolutionary consequences (Law, 2000). The Department will continue to monitor the age structure of the commercial and research catch, and changes to the selectivity of the gear may be warranted if negative trends in the age structure or other adverse effects are detected.

In an attempt to facilitate a local whole fish market for Herring, the Department may consider allowing additional gear types into the commercial Herring fishery (e.g. small cast nets have been proposed to the Commission) (Section 4.7.4). However, any changes in allowed gear must take careful consideration of the efficiency and selectivity of that gear, and its likely impacts on the age and size structure of the stock. A primary component of the Department's Herring management strategy includes allowing gear that primarily targets age four and older Herring. This allows all Herring the opportunity to spawn at least once before they become vulnerable to the fishery. In addition, alternative gear types may increase the rates of bycatch or habitat impacts, and these impacts should be considered prior to allowing new methods of take into the fishery. Any proposed changes in allowable commercial gear should be initially explored through the issuance of an experimental fishing permit through the Commission process. This avenue allows Department scientific staff to assess potential impacts to the stock and ecosystem prior to a regulatory change. See Chapter 9 (Section 9.1) for a discussion of the Commission's role in establishing alternative gear types and issuance of experimental fishing permits under this FMP.

7.8.4 Spatial Restrictions

No changes to the existing spatial restrictions on Herring fishing in San Francisco Bay (Section 5.5, Figure 5-3) are proposed as part of the FMP.

7.8.5 Temporal and Seasonal Restrictions

One of the goals of the FMP is to streamline regulations as appropriate. During the development of this FMP, the Department conducted a review of the existing regulations and sought input from various stakeholder groups, including permit holders, processors, the Department's Law Enforcement Division, recreational fishermen, and the conservation community through surveys, meetings, and public comment periods. Based on the feedback received, changes to the season dates are indicated in Table 7-4.

Table 7-4. Summary of changes to season dates in each management area.

Area	Dates Prior to FMP	Dates Established Under this FMP
San Francisco Bay	1700 on January 1 until 1200 on March 15	Herring fishing in all management areas will run from 1200 on Jan 2 to 1200 on March 15. The weekend closure will remain in effect in San Francisco Bay. If January 2 falls on a weekend, the fishery in San Francisco Bay will open at 1700 on the following Sunday.
Tomales Bay	1200 on December 26 until 1200 on February 22	
Humboldt Bay	1200 on January 2 until 1200 on March 9	
Crescent City	1200 on January 14 until 1200 on March 23	

Previously, each management area had its own season dates. This FMP establishes a single start and end date for all management areas. The start date is moved to January 2 for all management areas, with an end date of March 15. The weekend closure will remain in effect only in San Francisco Bay. If Jan 2 falls on a Friday or Saturday, the fishery in San Francisco Bay will open at 1700 on the following Sunday due to the weekend closure requirement.

7.8.6 Size and Sex

There are currently no limits on the size of Herring that can be retained by the fishery. However, the current mesh size limit begins to select fish at about 160 mm (6 in) body length, and fish are fully selected at about 180 mm (7 in). Given the schooling nature of Herring and the use of gill nets, both males and females are caught in the fishery. The commercial fleet is unable to catch only females, which are the target of the roe fishery. The Commission may choose to adjust the size of the gill net mesh to alter the size composition of commercial landings as a management tool in the future (see section 9.1).

7.8.7 Recreational Fishery

This FMP establishes a daily bag limit for recreational fishing. This FMP recommends a range between 0 and 100 lb (45-kg) daily bag limit, which is equivalent to up to ten gallons, or two 5-gallon buckets of Herring, each containing approximately 260 Herring. Based on input from stakeholders this is considered to be an appropriate amount to provide a reasonable and sustainable amount of recreational harvest for participants. This possession limit is also designed to be clear and easily enforceable. Currently, there are no estimates of the recreational catch available, but this possession limit will provide Department staff with a means of estimating recreational take via counting the number of recreational anglers observed during each spawning event.

Should the recreational sector continue to grow, or should there be additional concerns about the impact the recreational sector is having on the stock, Department staff may consider implementing additional restrictions on fishing effort. These may include only allowing recreational Herring fishing at certain times of the day, on certain days of the week, or establishing a recreational fishing season. Additionally, restrictions on gear types and configurations (such as cast nets) may be an effective and easily enforceable way to reduce the CPUE in the recreational Herring fishery.

7.8.8 Management Measures to Prevent Bycatch and Discards

Given the low levels of bycatch observed in the Herring fishery (Section 5.9), this FMP includes no additional management measures to reduce the amount or impact of bycatch. Bycatch collected in commercial Herring samples will be recorded and periodically updated in the Enhanced Status Report.

7.8.9 Management Measures to Reduce Habitat Impacts

Gill nets generally are set in shallow muddy bays. Muddy benthic habitats support a wide variety of invertebrate fauna that have varying degrees of susceptibility to and ability to recover from disturbance. Gill nets may also be set in areas with eelgrass and other submerged vegetation, which are vulnerable to disturbance by gill net gear (Section 2.13.3). Existing spatial restrictions on using gill nets to fish for Herring provide protection to roughly 13% of total eelgrass habitat in San Francisco Bay, including the beds in Richardson Bay and Belvedere Cove (Section 5.10.1, Figure 5-3). Other areas, such as Kiel Cove, Paradise, Brooks Island, and Point Richmond have eelgrass beds that may be impacted by gill net fishing. However, given the very short fishing season, which frequently lasts six weeks or less, as well as the established limit on the number of vessels in the gill net fleet, the potential for this type of damage is considered minimal. No additional management measures are proposed to reduce the habitat impacts from fishing activities. The primary threats to Herring habitat are from non-fishing activities that fall outside the scope and authority of this FMP (Section 5.10.2).

7.9 Management Procedure

Under this FMP, the authority for quota changes in all management areas is transferred from the Commission to the Department's Director (Section 9.1). Provided the proposed management change is in line with the management strategy described in this chapter, the Department will be able to adjust quotas as needed without a Commission rulemaking. This allows the Department to be more responsive to changes in the fishery, as well as to reduce the workload associated with routine management (Section 6.1.1). Other changes to the management of the fishery will still require the formal Commission process and approval, providing safeguards for the fishery, as defined in Chapter 9 of this FMP.

7.10 Continued Stakeholder Involvement

The MLMA directs managers to involve stakeholders in management decisions and the Herring fishery has benefited greatly from having a formal process for communication with stakeholders since the early years of the fishery. Yearly meetings with the DHAC should continue to be an integral part of the management cycle. When appropriate, Department staff will continue to meet once a year with the DHAC in order to present the data collected from that season, results of analyses conducted, and a recommendation for the quota based on the HCR. However, under the new HCR framework, some of the ecological and environmental data required for use in the predictive model are not available until late September. Therefore, the timing of DHAC meetings will move to late October or early November to allow Department staff enough time to conduct the necessary analyses and determine the quota for the coming season. Department staff should present the available data and describe the resulting SSB estimate, any quota changes for the next season, and the status of the various ecosystem indicators and their interpretation will be periodically updated in the Enhanced Status Report. The DHAC meeting will continue to be a forum for industry and Department discussion as well as exchange of information and ideas.

Chapter 8. Additional Management Needs and Future Research

8.1 Stock Size in Crescent City Harbor

While the stock in Crescent City Harbor was routinely fished between 1973 and 2002, surveys were not been conducted by Department staff to estimate SSB. Anecdotal reports suggest that this stock spawns in Crescent City Harbor along rocky riprap, rather than in shallow subtidal vegetation beds. The total spawning potential and whether the stock utilizes spawning habitat outside the harbor is unknown for this area. The age structure and growth rates are also unknown. These data are important and could be useful for making management decisions in this fishing area.

8.2 Changes in Size at Age and Impacts on Stock Health

Tomales and San Francisco Bays both experienced a decline in the abundance of larger, older fish between the mid-90s through the present. While the age structure in San Francisco Bay has shown some signals of recovery, size at age has continued to decline despite more than a decade of precautionary management (target of 5% or lower) intended harvest percentages. The loss of older fish in a population indicates an increase in mortality rates for those age classes. Increased mortality may arise from fishing or natural processes, and both increased natural mortality and declining size at age have been observed in other Herring stocks (Hay and others, 2012; Schweigert and others, 2002). Given the decrease in fishing pressure in California since the early 2000s it is possible that natural mortality has increased, though the cause of the mortality rate change is unknown.

The location of fishing is often nonrandom relative to spatial distributions of stocks; fishing is typically concentrated where biomass is greatest or most accessible. Fishing mortality is therefore selective with respect to both species and phenotypic variation within species (Jennings and Kaiser, 1998; Stokes and Elythe, 1993). Heavy fishing has been shown to have selective effects on certain phenotypic traits related to yield, most commonly growth rate, length- and age-at-sexual maturation, and fecundity (Law, 2007). Changes in fecundity have been noted in the San Francisco Bay stock. Reilly and Moore (1986) estimated fecundity at 113.5 eggs/g of body weight of female and male Herring, whereas in 2015 Department staff estimated 108.5 eggs/g of body weight. It is possible that larger fish, which are known to spawn earlier in the season, were subjected to higher fishing pressure when fishing was allowed earlier in the season, therefore less likely to reproduce successfully.

Environmental fluctuations may also play a role in the observed changes in length at age in San Francisco's Herring stock. Warmer waters, increased climate variability, pollution, or other unknown variables may have contributed to the reduction in growth rates and condition index that have been observed. Herring populations throughout British Columbia have also displayed a long-term decline in size-at-age, and it has been hypothesized that the food supply in the

CCE may have been reduced over the past two decades (Schweigert and others, 2002). More research is needed to understand the causes of observed changes in size and age distribution. Additional work is also needed to understand the impacts of changes in size and age on the Department's ability to interpret metrics of stock health, which are often based on historical observations.

8.3 Genetics and Stock Structure

Herring populations in California are managed as distinct stocks, though the true underlying population structure has never been verified. San Francisco Bay and Tomales Bay stocks occur within 80 km (50 mi) of one another and some efforts have been made to determine stock structure. Spratt (1981) noted that the growth rate of Tomales Bay Herring was significantly different than that of San Francisco Bay Herring and that this may be evidence that the Herring populations in the two bays are distinct. Reilly and Moore (1986) analyzed morphometric (measurement of body parts expressed as a ratio to total body length) and meristic (count of body parts such as fin rays, vertebrate, etc.) characteristics of California Herring from Fort Bragg Harbor and San Francisco, Tomales, and Humboldt Bays, in an attempt to detect differences in Herring from these locations. Analysis indicated that the northern populations (Humboldt Bay and Fort Bragg) could be separated from the southern populations (Tomales and San Francisco Bays) with an 85-87% success rate, but morphometric differences were not great enough to separate Herring from Tomales and San Francisco Bays. Moser and Hsieh (1992) used parasites as biological tags in a study of juvenile Herring off central California. The results suggested that Tomales and San Francisco Bay Herring are separate spawning stocks and generally remain separate while at sea. As DNA analyses techniques evolve it may be possible to determine the extent to which populations mix or use multiple bays for spawning.

There is a new body of evidence from northern populations of Herring that spawning aggregations separated by several weeks or more in timing exhibit genetic differentiation when using high resolution molecular markers (Petrou and others, in preparation). Given that spawn timing in San Francisco Bay spans months, these new markers may be used to evaluate if there is genetic structure by spawn timing or geography. These may help inform whether additional spatial or temporal considerations in management are necessary.

8.4 Oceanic Phase of California Herring

There is very little information available on the behavior, migration patterns, or distribution of California's Herring stocks when they emigrate from bays after spawning each winter. There is some evidence linking the San Francisco Bay winter spawning stock with Herring populations observed on summer feeding grounds in Monterey (Moser and Hsieh, 1992). This study also concluded that Herring in Tomales Bay are a separate stock that feeds offshore based on the observed parasites load. There is no information on the stocks in Humboldt Bay and Crescent City Harbor. Characterizing these dynamics might be a key future research endeavor that could help to refine the set of ecosystem indicators considered given the spatial overlap of Herring with their prey and predators. The recent development of high resolution, polymorphic single-nucleotide polymorphism markers (Petrou and others, in preparation) may provide information on spatial structure of California's Herring populations, including during oceanic phases.

8.5 Disease

Disease has significant effects on population abundance of some Herring stocks, particularly in Alaska (Marty and others, 2003). Herring are susceptible to epidemic diseases such as viral erythrocytic necrosis virus and viral hemorrhagic septicemia virus (VHSV) (Gustafson and others, 2006; Kocan and others, 1997). In Prince William Sound, Alaska, risk of disease was increased by poor body condition and very high recruitment levels prior to spawning (Marty and others, 2003). Recently, several fish diseases have been implicated as major constraints in limiting age structure and survival of Herring populations in Washington State. Hershberger and others (2002) identified a single-celled protist, *Icthyophonus hoferi,* and VHSV as endemic pathogens in Puget Sound Herring. *I. hoferi* is age dependent, increasing in incidence as the fish grows older. The recent emergence of a disease of this type could potentially explain the lack of older age classes (seven and older) in the San Francisco Bay populations despite very low harvest rates since the early 2000s. VHSV has been found in southern California stocks of Pacific Sardine (Cox and Hendrick, 2001). Herring from San Francisco Bay were tested for VHSV in the early 1990s and the virus was not found (W. Cox, pers. comm.). Updated pathological work in this area would be beneficial to understand the occurrence of disease in California Herring stocks.

8.6 Spatial Variability

Certain regions have been utilized for spawning disproportionately among locations in San Francisco Bay by the observed SSB, and those regions have shifted over time. In the past two decades, the majority of spawning (79% since 2000) has occurred in Marin County, which includes the areas of Richardson Bay and Tiburon Peninsula. Prior to that, from the late 1980s to the early 1990s, the San Francisco Bay Waterfront was the primary spawning region. It is unknown what causes spatial shifts across spawning habitats utilized by Herring in San Francisco Bay. There may be external influences, such as habitat alterations or other environmental cues, or shifts may occur due to the spatial structure of the stock, with certain sub-populations returning to specific locations year after year. For example, Spratt (1992) observed that a large storm in 1981 removed a large proportion of the submerged vegetation in Richardson Bay, and hypothesized that this shift in habitat contributed to the increased spawning along the San Francisco waterfront in the following ten or more years. The closure in Richardson

Bay to the Herring sac-roe fishery may have also contributed to the observed disparity between Marin County and the rest of San Francisco Bay. Populations with high levels of spatial structure may require lower or more evenly distributed harvest rates in order to maintain that structure (Ying and others, 2011), though this requires management at a smaller spatial scale than is usually practical. A Herring stock that spawns in only one location may also be more susceptible to localized disasters such as the 2007 Cosco Busan oil spill, which caused increased Herring embryo mortality (Incardona and others, 2012). A more in-depth analysis focused on spatial population dynamics, spawning habitats, and the diversity of spawning sites will improve management given the current reliance of the population on specific spawning sites, particularly Richardson Bay.

There is also little information on the extent to which Herring stocks utilize spawning grounds outside of San Francisco Bay. Anecdotal reports have indicated that spawning may occur in areas to the north and south of San Francisco Bay each year, as well as just outside of the mouth of San Francisco Bay in high outflow years, and spatial variability on this scale is difficult to detect with current resources. Given that Herring in San Francisco Bay are at the southern end of their range, there is a potential for range shifts in the future due to climate change. Monitoring changes in the spatial distribution of Herring spawns, even if only through anecdotal reports, may be useful in detecting range shifts.

8.7 Relationship between Habitat Availability and Spawning

Herring utilize eelgrass and various algae in addition to other physical and biological spawning habitat. However, the extent to which the availability of these spawning habitats influences spawning behavior and magnitude is unknown. Eelgrass habitat may be an important ecosystem indicator for Herring stocks, especially in Tomales and Humboldt Bays, where it serves as a primary spawning habitat for Herring. Sporadic estimates of eelgrass coverage are available in San Francisco Bay (Merkel and Associates, 2014), as well as for Tomales Bay and Humboldt Bay, but these datasets do not represent a continuous time series. However, the Department has surveyed the biomass of vegetation beds yearly in San Francisco Bay since 1980, and conducted similar surveys every few years in Tomales Bay until 2005. The data from these surveys could be analyzed to understand variability in these bed over time, and to explore correlation between vegetation and environmental conditions as well as vegetation and estimated Herring SSB. In the future, high-resolution satellite data may provide a way to develop a longer-term eelgrass time series that could improve understanding of how Herring biomass and eelgrass co-vary, improving habitat management capabilities.

8.8 Aging Herring Using Scales

In addition to otoliths, scales have been used to reliably age fish (Ricker, 1975), and an independent review of a stock assessment model for San Francisco Bay suggested that the Department explore using scales to estimate the age distribution of Herring stocks. This methodology could be considered by Department staff in the future (Appendix C). Switching to a new aging methodology would require upfront costs in terms of training and validation, but might result in a reliable way to obtain age distributions for Herring stocks over the long term. Age structure is an important indicator of stock health and using an equal or more reliable way to age Herring would be beneficial for the longevity the Herring program.

8.9 Understanding the Impact of Marine Mammal Exclusion Devices in the HEOK Fishery

A representative of the HEOK fishery has petitioned the Commission to allow the use of marine mammal deterrent devices provided they meet NOAA guidelines (marine mammal interactions are primarily governed by Federal statute). California Herring regulations (CCR Title 14 §163 (f)(G)) currently specify that the use of marine mammal deterrents during Herring fishing is not allowed. The Commission issued an experimental gear permit to deploy seal exclusion nets around HEOK rafts during the 2004-05 season and was subject to annual renewal in subsequent seasons. These nets had a rigid structure and large openings in the mesh to minimize bycatch impacts while allowing Herring to freely enter and exit the structure. However, additional trials and directed study are required to optimize the size and configuration of the structures and to understand bycatch and habitat impacts prior to any regulatory change.

8.10 Improving our Understanding of Predator-Prey Relationships

One of the key areas of uncertainty identified in the development of this FMP was the predator-prey dynamics of Herring in California. One of the central questions that arose was whether, and under what circumstances Herring as a specific prey item are a limiting factor for predators in the central CCE. Future research may focus on: 1) whether there is evidence that predator populations fluctuate in response to the Herring population abundance in California, and if so, 2) what predators, and 3) at what levels of Herring abundance do those predators become food limited. Additional research also needs to be conducted to understand the interactions between other small pelagic forage species' relative abundance in relation to Herring. It may be particularly useful to establish winter diet composition data for Herring predators in central and northern California (Appendix R).

Chapter 9. Implementation, Review and Amendment

Section 7087 of the MLMA states that each FMP shall include a procedure for review and amendment of the plan, as necessary and shall specify the types of regulations that the Department can adopt without a plan amendment. This section describes those regulations that can be adopted without a FMP amendment, the changes that require an amendment, and the process for plan amendment.

9.1 FMP Implementation: Quota Adjustment and Regulatory Changes Not Requiring Amendment

Upon adoption of the FMP and implementing regulations, the Director of the Department will set annual fishing quotas for all management areas in accordance with the management strategy described in Chapter 7, including the use of the HCR framework in San Francisco Bay (Section 7.7). This does not require changes to the CCR through the formal Commission rulemaking process. Changes, if any, to the San Francisco Bay quota will be set on or before November 1 each year. Herring permit holders and the public will be notified as early as feasible to assist permit holders and buyers with planning for the season. Notification will be posted on the Department's website once a final determination has been made. The notification will provide a summary of how the HCR was applied to determine the quota, and information on the status of additional environmental indicators, if available.

An important component of this FMP is that it provides the Department the ability to respond to changing conditions, both environmental and market driven. Regulation changes may be implemented as necessary to meet the management objectives described in Chapter 7 without FMP amendment. This includes regulations that: 1) manage fishery impacts to Herring habitat, 2) manage bycatch in the fishery, 3) establish record keeping requirements, 4) provide for the orderly conduct of the fishery, and 5) facilitate market access. These changes can only be made if they do not jeopardize the sustainability of the stock or negatively impact the ecosystem. Potential examples of future regulatory changes that may occur are provided in Table 9-1. The anticipated impacts of each regulatory change should be carefully considered, and the changes must maintain consistency with the management objectives and strategies outlined in this FMP. The Department will continue to seek input from various constituents should any management change be considered.

Table 9-1. Descriptions of example management measures (changes) that may be considered by the Commission via a rulemaking process under this FMP.

Type of Change	Potential Rationale	Considerations
Gear changes, experimental fishing permits	There is desire by permit holders to reach new markets via an alternative gear type.	How does this change alter the age and lifetime reproductive capacity of the stock?
		How does this change alter the bycatch levels of the fishery?
		How does this change alter the habitat impacts of the fishery?
Change to season dates	There is a shift in the prime spawning season (earlier or later).	How does this change impact older, larger Herring, which typically spawn early in the season?
		How does this change impact market access?
Change to weekend closure times	There is a desire by permit holders to alter or eliminate the weekend closure.	How does this change impact other activities on the bay?
		How does this change alter the temporal refuge spawning schools may get receive?
		How does this change impact market access?
		How does this change impact the cost of management for the Department?
Additional regulations for recreational fishery	The total recreational catch continues to increase, causing concern for the status of the resource.	How does this regulatory change impact the goal of providing for a satisfying and sustainable recreational experience for participants?
		Are the restrictions consistent with those applied in the commercial fishery?

The goal of this FMP is to provide an adaptive management framework that is applicable to a wide range of future management scenarios (Chapter 7). Unforeseen events may occur that require additional management action by the Department. For example, the HCR framework does include an emergency closure provision for the San Francisco Bay management area. This can be utilized by setting the quota to zero and does not require a Commission rulemaking process. The HCR framework is based on precautionary management principles, therefore this type of management response would only be considered under extreme conditions, such as an oil spill, natural disaster, or severe ecological changes. Under these conditions, the recreational fishery may also be closed to limit all fishery impacts on the stock through an emergency rulemaking process. The Department and the Commission also retain authority to promulgate emergency regulations as needed (FGC §240).

This FMP also allows the Department to continue to adapt the SSB estimation protocol as needed to changing conditions both in the stock as well as in the fishery. Application of the HCR framework in San Francisco Bay requires the use of spawn deposition surveys as the primary assessment method to estimate annual spawning biomass (Table 6-1, Section 7.6). The monitoring procedure has been developed over the last 40 years and has been refined over time to adjust to changes in both the Herring population and staffing availability (Watters and others, 2004). If participation in the Herring fishery continues to decrease or stop all together, the Department may allocate fewer staff to monitoring Herring in San Francisco Bay. Under this scenario, the Department may choose to switch to the Rapid Spawn Assessment Method described in Section 6.2.1.1 without an amendment to the FMP.

9.2 When an Amendment is Required

A change to any components of the HCR framework identified in Section 7.7.1, including the cutoff, minimum quota, line slope, or maximum target harvest rate, will require a FMP amendment. As new information becomes available, MSE analysis used to develop the HCR can be updated to ensure that the desired fishery management objectives continue to be met, and to determine any potential need for a FMP amendment. Updating the MSE analysis however does not require a FMP amendment, and only a change to the HCR framework would require amending the FMP. An updated MSE analysis could help the Department determine if the HCR was performing as expected or to evaluate performance should conditions change in the future.

An important component of this FMP is the inclusion of ecosystem indicators in the decision tree as well as in ecosystem status reports for the San Francisco Bay stock. Ecosystem-based fishery management is an evolving science, and new data and informative indicators on the environmental conditions that affect Herring or their predators may be developed. Additionally, climatic changes may alter the relationships between indicators of Herring population health and indicators that are informative to management. Department staff may choose to include additional and/or remove existing environmental indicators to the decision tree or to the matrix of EFI for understanding ecological and environmental conditions without an amendment to the FMP (Sections 7.7.3). This can be done provided they have been shown to have either: a) direct and significant relationship to metrics of population health through peer reviewed analysis, or b) direct dietary connection at ecologically relevant spatial and temporal scales between the predator and the San Francisco Bay stock. Department staff may also remove indicators that no longer inform stock health. This can happen as ecological conditions change (regime shift as an example) and correlations between indicators and Herring population metrics are no longer present. Additionally, as the science evolves the Department may adjust the magnitude of changes to the quota recommended by the decision tree up to the limits defined in Section 7.7.2.3, provided the supporting science is clearly documented (Appendix R).

This FMP has described options to address management needs outside of the San Francisco Bay management area through a tiered management system. This approach matches the level of Department management effort to the risk posed by the fishery. Chapter 7 outlines how management effort may increase should fishing activity change. Active management in Tomales Bay, Humboldt Bay, or Crescent City Harbor may be required if fishery participation rates increase or to meet a Commission petition for larger quotas.

A significant increase in fishing pressure may require the Department to increase monitoring effort, and to reallocate staff to address monitoring needs in those areas. A FMP amendment would be required if a quota change petition exceeds what is recommended in this FMP for the northern stocks and/or if there is a desire to transition one of these areas to a Tier 3 management area. Development of a HCR for any of the northern management areas would also require an amendment. Many of the features for Tier 3 management areas in this FMP were developed and tested specifically for San Francisco Bay (using location specific data and indicators) and may not be appropriate for the northern management areas. MSE testing would also be necessary to develop a HCR that meets the management objectives for those fisheries, and location-specific environmental and ecological indicators will need to be explored. Thresholds and management objectives would also have to be developed during MSE testing to set levels of harvest beyond what is recommended in this FMP, which is currently based on historical data and landings.

9.3 Process for Amendment

FGC Sections 7075-7078 describe the process required to amend a FMP. The Department, fishery participants and their representatives, fishery scientists, or other interested parties may propose amendments to a FMP to the Department or the Commission. The Commission shall review any proposal submitted and may recommend that the Department develop a plan amendment to incorporate the proposal. Existing Department and Commission workloads and priorities may impact the response to these petitions.

In developing any proposed amendment, the Department will solicit input from California Native American Tribes, stakeholders, the public, and the Commission. Prior to submitting a proposed amendment to the Commission, the Department will submit it to peer review unless the Department determines the amendment may be exempted pursuant to FGC §7075(c). If the amendment is exempt, the Department shall submit reasons to the Commission. The Commission will make any proposed amendment available to the public for review at least 30 days prior to a hearing. The Commission will hear any proposed amendment within 60 days of receipt and will hold at least two public hearings prior to adoption or rejection. The Commission may adopt the amendment at the second public hearing or at any duly noticed subsequent meeting. If the Commission rejects an amendment, it will return it to the Department for revision and resubmission together with a written statement of reasons for the rejection. The Department will revise and resubmit the amendment to the Commission within 90 days of the rejection. The revised amendment shall be subject to the same review and adoption requirements described above.

9.4 List of Inoperative Statutes

This FMP will render the following sections of the Fish and Game code inoperative, as applied to only the Herring fisheries, once the implementing regulations are in place:

8389. Herring Eggs; Taking Restrictions (a) Herring eggs may only be taken for commercial purposes under a revocable, nontransferable permit subject to such regulations as the commission shall prescribe. In addition to the license fees provided for in this code, every person taking herring eggs under this section shall pay a royalty, as the commission may prescribe, of not less than fifty dollars ($50) per ton of herring eggs taken.
(b) Whenever necessary to prevent overutilization, to ensure efficient and economic operation of the fishery, or to otherwise carry out this article, the commission may limit the number of permits which are issued and the amount of herring eggs taken under those permits.
(c) In limiting the number of permits, the commission shall take into consideration any restriction of the fishing area and safety of others who, for purposes other than fishing, use the waters from which herring eggs are taken.
(d) Every person operating under a permit issued pursuant to this section is exempted from the provisions of Chapter 6 (commencing with Section 6650) of Part 1 of Division 6 for aquatic plants taken incidental to the harvest of herring eggs. (AM ’88)

8550. Herring may be taken for commercial purposes only under a permit, subject to regulations adopted by the commission. The commission may, whenever necessary to prevent overutilization, to ensure efficient and economic operation of the fishery, or to otherwise carry out this article, limit the total number of permits that are issued and the amount of herring that may be taken under the permits.
The commission, in limiting the total number of permits, shall take into consideration any restriction of the fishing area and the safety of others who, for purposes other than fishing, use the waters from which herring are taken.
(Amended by Stats. 1996, Ch. 870, Sec. 38. Effective January 1, 1997.)

8550.5. (a) A herring net permit granting the privilege to take herring with nets for commercial purposes shall be issued to licensed commercial fishermen, subject to regulations adopted under Section 8550, as follows:
(1) To any resident of this state to use gill nets, upon payment of a fee of two hundred sixty-five dollars ($265).
(2) To any nonresident to use gill nets, upon payment of a fee of one thousand dollars ($1,000).
(b) The commission shall not require a permit for a person to be a crewmember on a vessel taking herring pursuant to this article.
(Amended by Stats. 2000, Ch. 388, Sec. 17. Effective January 1, 2001.)

8552. (a) It is unlawful to take herring for roe on a vessel unless the operator holds a herring permit issued by the department pursuant to commission regulations. The permit may be transferred pursuant to Sections 8552.2 and 8552.6.
(b) No person may be issued more than one herring permit, and the department shall not issue a herring permit to more than one person except as provided in Section 8552.6.
(c) Herring permits shall only be issued to and shall be held only by a natural person.
(d) Herring permits shall not be used as any form of security for any purpose, including, but not limited to, financial or performance obligations.
(e) The permittee shall be on board the vessel at all times during herring fishing operations, subject only to exceptions provided for in this code and regulations adopted under this code.
(Amended by Stats. 1988, Ch. 1505, Sec. 3.)

8552.2. Notwithstanding Section 1052, a herring permit may be transferred from a herring permitholder to a nonpermitholder having a minimum of 20 or more herring fishery points, as follows: The permitholder shall mail, by certified or registered mail, to the department and every individual listed on the department's list of maximum 20 or more point herring fishery participants, his or her notice of intention to transfer his or her herring permit, which notice shall specify the gear type to be used under the herring permit; the name, address, and telephone number of the transferor and proposed transferee; and the amount of consideration, if any, sought by the transferor. Sixty days after mailing the notice, the transferor may transfer the permit to any person having 20 or more experience points without the necessity for giving further notice if the transfer occurs within six months of the date the original notice was given. Transfers after that six-month period shall require another 60-day notice of intention to be given. No person may hold more than one herring permit. A true copy of the notice of intention to transfer a permit shall be filed with the department by the transferor under penalty of perjury and shall be available for public review.

(Amended by Stats. 1989, Ch. 207, Sec. 4. Effective July 25, 1989.)

8552.3. The commission may, in consultation with representatives of the commercial herring roe fishery, and after holding at least one public hearing, adopt regulations intended to facilitate the transfer of herring permits, including, but not limited to, regulations that would do the following:
(a) Allow an individual to own a single permit for each of the different herring gill net platoons in San Francisco Bay.
(b) Eliminate the point system for qualifying for a herring permit.
(c) Allow a herring permit to be passed from a parent to child, or between spouses.
(Amended by Stats. 2016, Ch. 50, Sec. 42. (SB 1005) Effective January 1, 2017.)

8552.4. Herring permits that are revoked or not renewed may be offered by the department for a drawing to persons having 20 or more experience points in the fishery on the first Friday of August of each year.
(Amended by Stats. 1989, Ch. 207, Sec. 5. Effective July 25, 1989.)

8552.5. The commission shall revoke any herring permit if the holder of the herring permit was convicted of failing to report herring landings or underreported herring landings or failed to correctly file with the department the offer or the acceptance for a permit transferred pursuant to Section 8552.2.
(Added by Stats. 1988, Ch. 1505, Sec. 6.)

8552.6. (a) Notwithstanding Section 8552, a herring permit may be issued to two individuals if one of the following criteria is met:
(1) The individuals are married to each other and file with the department a certified copy of their certificate of marriage and a declaration under penalty of perjury, or a court order, stating that the permit is community property.
(2) The individuals meet both of the following requirements:
(A) They are both engaged in the herring roe fishery either by fishing aboard the vessel or by personally participating in the management, administration, and operation of the partnership’s herring fishing business.
(B) There is a partnership constituting equal, 50 percent, ownership in a herring fishery operation, including a vessel or equipment, and that partnership is demonstrated by any two of the following:
(i) A copy of a federal partnership tax return.
(ii) A written partnership agreement.
(iii) Joint ownership of a fishing vessel used in the herring fishery as demonstrated on federal vessel license documents.
(b) For purposes of this section, a herring permit does not constitute a herring fishing operation. A herring permit may be transferred to one of the partners to be held thereafter in that partner’s name only if that partner has not less than 10 points computed pursuant to paragraph (2) of subdivision (a) of Section 8552.8

and there has been a death or retirement of the other partner, a dissolution of partnership, or the partnership is dissolved by a dissolution of marriage or decree of legal separation. A transfer under this section shall be authorized only if proof that the partnership has existed for three or more consecutive years is furnished to the department or a certified copy of a certificate of marriage is on file with the department and the permit is community property as provided in subdivision (a). The transferor of a permit shall not, by reason of the transfer, become ineligible to participate further in the herring fishery or to purchase another permit.
(c) Notwithstanding subdivision (b), in the event of the death of one of the partners holding a herring permit pursuant to this section, where the partnership existed for longer than six months but less than three years and the surviving partner does not have the minimum points pursuant to subdivision (b) to qualify for a permit transfer, the permit may be transferred on an interim basis for a period of not more than 10 years to the surviving partner if an application is submitted to the department within one year of the deceased partner's death and the surviving partner participates in the fishery for the purpose of achieving the minimum number of points to be eligible for a permit transfer pursuant to Section 8552.2. The interim permit shall enable the surviving partner to participate in the herring fishery. At the end of the interim permit period, the surviving partner, upon application to the department, may be issued the permit if he or she has participated in the fishery and gained the minimum number of experience points for a permit.
(Amended by Stats. 2001, Ch. 753, Sec. 20. Effective January 1, 2002.)

8552.7. The department shall reissue a herring permit which has been transferred pursuant to Section 8552.2 or 8552.6 upon payment of a transfer fee by the transferee of the permit. Before April 1, 1997, the transfer fee is two thousand five hundred dollars ($2,500), and, on and after April 1, 1997, the transfer fee is five thousand dollars ($5,000). The fees shall be deposited in the Fish and Game Preservation Fund and shall be expended for research and management activities to maintain and enhance herring resources pursuant to subdivision (a) of Section 8052.
(Amended by Stats. 1994, Ch. 360, Sec. 1. Effective January 1, 1995.)

8552.8. (a) For purposes of this article, the experience points for a person engaged in the herring roe fishery shall be based on the number of years holding a commercial fishing license and the number of years having served as a crewmember in the herring roe fishery, and determined by the sum of both of the following:
(1) One point for each year in the previous 12 years (prior to the current license year) that the person has held a commercial fishing license issued pursuant to Section 7852, not to exceed a maximum of 10 points.

(2) Five points for one year of service as a paid crewmember in the herring roe fishery, as determined pursuant to Section 8559, three points for a second year of service as a paid crewmember, and two points for a third year as a paid crewmember, beginning with the 1978–79 herring fishing season, not to exceed a maximum of 10 points.
(b) The department shall maintain a list of all individuals possessing the maximum of 20 experience points and of all those persons holding two points or more, grouped in a list by number of points. The list shall be maintained annually and shall be available from the department to all pointholders and to all herring permittees. All pointholders are responsible for providing the department with their current address and for verifying points credited to them by the department.
(c) A herring permittee may use the department's list and rely upon that list in making offers for transfer of his or her permit until the date of the annual distribution of the new list. On and after the date of the annual revision of the list, the permittee shall use the new list.
(d) The point provisions in this section are for purposes of sale of a permit or transfer to a partner of a coowned permit.
(Amended by Stats. 2000, Ch. 388, Sec. 18. Effective January 1, 2001.)

8553. The commission may make and enforce such regulations as may be necessary or convenient for carrying out any power, authority, or jurisdiction conferred under this article.
(Added by Stats. 1973, Ch. 733.)

8554. The commission, in adopting regulations for the commercial herring fishery, shall provide for the temporary substitution of a permittee to take herring, if the permittee is ill or injured, by a crewmember aboard the vessel operated by the permittee. The commission may require that proof of the illness or injury be substantiated to the satisfaction of the department.
(Added by Stats. 1986, Ch. 725, Sec. 3.)

8556. Notwithstanding any other provision of law, the commission shall determine, by regulation, if drift or set gill nets may be used to take herring for commercial purposes. The commission may also determine, by regulation, the size of the meshes of the material used to make such gill nets.
(Added by Stats. 1976, Ch. 882.)

8557. Notwithstanding any other provision of law, the commission shall determine if round haul nets may be used to take herring in Districts 12 and 13 and the conditions under which those nets may be used.
(Amended by Stats. 1987, Ch. 269, Sec. 17.)

8558. (a) There is established a herring research and management account within the Fish and Game Preservation Fund. The funds in the account shall be expended for the purpose of supporting, in consultation with the herring industry pursuant to Section 8555, department evaluations of, and research on, herring populations in San Francisco Bay and those evaluations and research that may be required for Tomales Bay, Humboldt Bay, and Crescent City and assisting in enforcement of herring regulations. The evaluations and research shall be for the purpose of (1) determining the annual herring spawning biomass, (2) determining the condition of the herring resource, which may include its habitat, and (3) assisting the commission and the department in the adoption of regulations to ensure a sustainable herring roe fishery. An amount, not to exceed 15 percent of the total funds in the account, may be used for educational purposes regarding herring, herring habitat, and the herring roe fishery.
(b) The funds in the account shall consist of the funds deposited pursuant to Sections 8558.1, 8558.2, and 8558.3, and the funds derived from herring landing fees allocated pursuant to subdivision (a) of Section 8052.
(c) The department shall maintain internal accountability necessary to ensure that all restrictions on the expenditure of the funds in the account are met.
(Amended by Stats. 2017, Ch. 26, Sec. 32. (SB 92) Effective June 27, 2017.)

8558.1. (a) No person shall purchase or renew any permit to take herring for commercial purposes in San Francisco Bay without first obtaining from the department an annual herring stamp. The fee for the stamp shall be one hundred dollars ($100). The revenue from the fee for the herring stamps shall be deposited into the herring research and management account established pursuant to Section 8558.
(b) This section shall become operative on April 1, 1997.
(Added by Stats. 1996, Ch. 584, Sec. 2. Effective January 1, 1997.)

8558.2. The amount of the difference between fees for nonresidents and resident fees, collected pursuant to Section 8550.5, shall be deposited into the herring research and management account established pursuant to Section 8558, and all fees for San Francisco Bay herring permit transfers, collected pursuant to Section 8552.7, shall also be deposited into the herring research and management account.
(Added by Stats. 1996, Ch. 584, Sec. 3. Effective January 1, 1997.)

8558.3. One-half of all royalties collected by the department from the roe-on-kelp fishery collected pursuant to paragraph (2) of subdivision (f) of Section 164 of Title 14 of the California Code of Regulations shall be deposited into the herring research and management account established pursuant to Section 8558.
(Added by Stats. 1996, Ch. 584, Sec. 4. Effective January 1, 1997.)

8559. The commission, in determining experience requirements for new entrants into the herring fishery after January 1, 1987, shall require that any person seeking a permit to operate a vessel to take herring and claiming crew experience shall demonstrate, to the satisfaction of the department, proof of payment as a crewmember in the herring fishery based on tax records or copies of canceled checks offered and accepted as payment for service on a crew in the California herring roe fishery.
(Added by Stats. 1986, Ch. 725, Sec. 5.)

Chapter 10. Analysis of Management Action and Alternatives

Per CEQA, an environmental document need not consider every conceivable alternative to a project. Rather an environmental document must: consider a range of reasonable alternatives that meet most or all of the project's objectives; substantially avoid or lessen the proposed project's potentially significant negative effects; be feasible to implement based on specific economic, social, legal and/or technical considerations; and foster informed decision making and public participation. It is not required to consider alternatives which are infeasible. The discussion of alternatives in this document will focus primarily on different management actions that could be modified to either improve the economics of the fishery or reduce negative environmental effects of the project. All commercial harvest alternatives contain common elements with the proposed project with only selected elements of the management framework considered as alternatives. This document examines in detail only the alternatives that could feasibly attain most of the basic objectives of the project. The document provides information about each alternative to allow meaningful evaluation, analysis, and comparison with the proposed project and does not consider alternatives whose effect cannot be reasonably ascertained and whose implementation is remote and speculative.

10.1 Summary of Potential Environmental Impacts of the Proposed Project

Overall, the proposed project is not anticipated to have any significant impacts on the environment. Additionally, implementation of the proposed project is expected to benefit natural resources held in trust for the people of California when compared to existing conditions. This section is intended to summarize the analysis contained throughout this document, with a focus on the potential for significant impact.

10.1.1 Effects to the Herring Population

Overall, this FMP is not anticipated to cause any significant impact to the health of the Herring population. There is no anticipated change to overall fishing effort. In fact, the season will be shortened a few days from the current regime, and overall fishing effort may decrease due to an anticipated reduction in fleet size. Additionally, the quotas are set at levels anticipated to ensure recovery of stock if needed, buffer against uncertainty in the future due to climate change scenarios, as well as support higher performance in terms of long-term stock health.

While the FMP does anticipate a scheme for allowing increased fishing in areas where fishing (at least in recent history) has not been occurring, for example Crescent City and Humboldt Bay, the management measures put in place by this FMP ensure that fishery will progress only at a level that is sustainable for the Herring population. This includes conservative, precautionary initial quotas until monitoring data supports raising the fishing level.

This FMP does not authorize any changes to current gear types. In particular, net mesh size, which has the potential to impact the age of Herring targeted by the fishery, will remain the same as currently used.

In sum, the proposed project will not cause any significant impacts on the Herring population in California.

10.1.2 Effects on Predator Populations

Herring play a role in the CCE as a forage stock for mid- to upper-trophic level predators. However, this FMP is not anticipated to cause any significant impact on predator populations dependent on Herring. The HCR is set to put limitations on Herring fishing and minimize any impact on the forage base, even when Herring stocks are low. Additionally, the quota cap may be beneficial to predators by allowing them to feed more on Herring when Herring are abundant. Furthermore, the CCE is resilient to fluctuations in forage fish abundance because so many species make up the forage base available to predator populations.

In sum, the FMP is designed to ensure that fishing mortality does not negatively affect the stock's role as forage, and will not have any significant impacts on the predator populations in California.

10.1.3 Effects on Marine Habitats

Gill nets may be set in areas with submerged vegetation as well as a variety of invertebrate benthic fauna that may be susceptible to disturbance. Eelgrass is one example of submerged vegetation that could be impacted by Herring fishing activities. However, given the short fishing season as well as the proposed limits on the number of vessels in the fleet, the anticipated damage to benthic habitats is considered minimal. Much of the available eelgrass habitat area is closed to the commercial Herring fishery. While localized areas subject to intense fishing may be vulnerable to short-term effects, no data exists to quantify these impacts, and the limited depths associated with eelgrass beds also limits the fishing activity and potential impact from that activity. Regarding benthic fauna, soft-bottom benthic communities impacted by Herring fisheries are dynamic and anticipated to recover quickly from non-continuous disturbances.

In sum, the FMP is designed to ensure the Herring fishery does not negatively impact marine habitats and associated communities, and will not have any significant impacts on marine habitats.

10.1.4 Effects on Non-Target Sensitive Species

The nets set in the gillnet sector may have interaction with young salmonids in San Francisco Bay, including listed species of salmon and steelhead. However, the peak timing of smolt emigration typically occurs after the Herring fishing season is ended. Additionally, smolts tend to remain in main channels and move quickly through the Bay, and are unlikely to occur in the nearshore areas where gill nets are often set. Salmon smolts that do occur in San

Francisco Bay during the Herring fishing season are also too small to be vulnerable to Herring gill nets due to the allowable mesh size. As a result, the FMP is unlikely to have impacts to non-target sensitive species.

10.1.5 Growth Inducing Effects

The proposed FMP is not expected to result in potentially significant growth inducing affects. The proposed project could foster some very limited economic activity, but that incremental affect would not be of a magnitude that it would stimulate the establishment of new businesses, population growth, or the construction of additional housing. In addition, no project characteristics are likely to remove obstacles to population growth or encourage or facilitate other activities that could significantly affect the environment, either individually or cumulatively. Any increase in fishing activity is not expected to be significant relative to existing conditions in and around the Herring fishery.

10.1.6 Significant Irreversible Environmental Effects

CEQA Guidelines section 15126(f) requires that the proposed project identify potential impacts that could result in significant irreversible environmental changes, including the use of non-renewable resources and the irretrievable commitment of resources. An irreversible commitment of resources is one that cannot be reversed, except perhaps in the extreme long term (millions of years). The classic instance is when a species becomes extinct; this is an irreversible loss. Irretrievable commitments are those that are lost for a period of time. The proposed project would not result in significant irreversible environmental changes or irretrievable commitments of environmental resources. The project is designed to avoid significant adverse impacts to other species, their habitat, and listed or locally unique species.

10.1.7 Short-term Uses and Long-term Productivity

CEQA Guidelines section 15126(e) requires that the cumulative and long-term effects of the proposed project that could affect the state of the environment, could narrow the range of beneficial uses of the environment, or that could pose long-term risks to health or safety be addressed. The proposed project will not affect the variety of short-term uses currently available, nor are any significant impacts expected to occur. In addition, the proposed project will not adversely affect long-term productivity of statewide populations of the targeted species, as this FMP is designed to bring fish populations and fishery participants into a balance that promotes sustainability.

10.1.8 Cumulative Impacts

In this section, the proposed project is analyzed in relation to other major projects in the region. Cumulative effects on environmental resources can result from the incremental effects of the project when added to other past, present, and reasonably foreseeable future projects in the area. Cumulative effects can result from individually minor but collectively significant actions over a period of time.

Dredging and dredge materials are one of the primary threats to Herring habitat in the Bay. However, the threat from these activities is minimized and avoided by work windows limiting dredging activities to times when biological resources are not present or least sensitive to disturbance. Additionally, projects not incompliance with the LTMS must consult with the appropriate resource agency for additional recommendations to avoid potential impacts.

Boating activities may reduce vegetation beds that are the preferred spawning habitat of Herring stocks in some locations. In particular, boats can shade and provide light-limiting conditions. Moorings can disturb eelgrass beds, causing barren patches in in eelgrass meadows. Additionally, boat propellers, anchors, and anchor chains can damage vegetation beds. Aquaculture activities may also have a negative impact on eelgrass density. However, aquaculture activities in California are regulated to minimize impacts to eelgrass habitat.

In sum, cumulative effects of the proposed project are not expected to be cumulatively considerable, that is, significant, when compared to the additional proposed projects described above.

10.2 No Project Alternative

The No Project Alternative is the existing regulations governing the Herring fishery at the time of the development of this FMP. These regulations include rules for the harvest of Herring for roe products, harvest of HEOK, and the harvest of Herring for fresh food, bait, and pet food. The No Project Alternative establishes fishing quotas by area and permit type, based on assessments of the spawning populations of Herring in San Francisco Bay. Set quotas for this alternative for Tomales Bay, Humboldt Bay, and Crescent City Harbor management areas are 350 tons, 60 tons, and 30 tons, respectively. Permits in San Francisco Bay in this project are limited and divided into platoons, which the permit holders fish on alternate weeks, which limits the number of vessels on the bay at any given time (Section 5.3.1). Finally, gill nets are the only authorized gear for the commercial fishery in the No Project Alternative.

Biomass surveys are performed during the spawning season in San Francisco Bay, and based on the data collected from these surveys, recommendations were sent to the Commission with quotas ranging from 0-10%. The Commission would set the final quota after considering environmental conditions, the Herring population's age class structure, and other factors. While prior management policy for Herring had many desirable aspects, when to reduce quotas below a 10% target harvest rate was not defined, nor had harvest limit thresholds been established in regulation.

The No Project Alternative does not have a daily or possession recreational Herring bag limit, therefore the potential for a participant to take hundreds of pounds of fish per day exists. Additionally, the gear types allowed include any method that is legally defined within statute or the regulations, although the primary methods for targeting Herring by sport fisherman are cast net and hook and line. Finally, there are no seasonal restrictions for targeting Herring under the No Project Alternative. For more information on the recreational sector, see Sections 4.6, 4.7.6, 5.8, 6.2.2.5 and 7.8.7.

10.2.1 Environmental impacts of No Project Alternative compared to proposed project (Summary)

The No Project Alternative represents the baseline activity (existing regulations at the time of development of this FMP), and therefore is not anticipated to cause additional environmental impacts. The existing regulations were analyzed per CEQA when they were finalized in 1998. An environmental document was certified and each year in which the Department made recommendations for a fishery quota change a supplemental document was produced to analyze the changes to the quota and these changes had to be approved through amended regulations. The following is a summary of the environmental effects analyzed in those CEQA documents that are relevant to the proposed project. For more detailed information and links to the prior CEQA documents produced on the Herring fishery regulations, please go to the Department website (https://www.wildlife.ca.gov/Fishing/Commercial/Herring).

10.2.2 Biological Effects

Potential environmental impacts to biological resources exist in all geographical areas that support commercial Herring fisheries. This is because Herring populations can fluctuate widely and play an important role in many marine food webs. Additionally, and for the purposes of this analysis, all geographic areas will be treated the same, since Herring utilize similar habitats in each area and sensitive species are fairly comparable due to the biogeographical region in which the fisheries operate. The potential impacts may be divided into four categories: effects on the population, effects of predator populations, effects on marine habitat, and effects on sensitive species.

10.2.2.1 Effects to Herring Population

The primary effects the No Project Alternative has on the Herring population are attributed to fishing pressure and environmental influences. Herring stocks may become unstable under fishing pressure, which could lead to collapsing stocks. The threat from fishing pressure is greatest when fisheries are data limited and managers cannot act quickly enough in the absence of independent stock assessment techniques. Similar to the proposed project, the No Project Alternative addresses these potential stock effects by using a conservative management strategy and employing a variety of independent stock assessment techniques. Annual stock assessment (SSB estimate and determination of population parameters, such as age structure) is conducted in the principal fishing area of San Francisco Bay. If a stock collapse is detected, then fishery closures are implemented to protect the population.

Changing environmental conditions from year to year can pose challenging problems for fishery managers, as Herring stocks could decline or be overtaxed due to fishing pressure in combination with environmental influences, such as El Niño. However, the No Project Alternative uses the Commission's emergency regulatory authority to close a fishery or set provisional quotas to decrease fishing pressure during times of environmental stress. Strictly relying on Commission actions is a less effective conservation strategy than the proposed project, which uses ecological indicators and predictive modeling to adjust the quotas and more proactively manage the stock (Section 7.7.2)

The final effect on the Herring population from the No Project Alternative is fishing mortality from fish caught by lost gill nets and illegal take beyond established quota limits. This Alternative, as with the proposed project, addresses these concerns by providing intensive enforcement effort as a part of Herring management.

10.2.2.2 Effects on Predator Populations

Harvesting Herring not only affects the Herring populations, but potentially affects a number of other species within the ecological food web. These impacts include reduced availability of Herring eggs for predators such as birds, fishes, and marine invertebrates as well as a reduction in Herring consumed by fishes, birds, and marine mammals. The No Project Alternative reduces negative trophic level impacts of Herring as forage by setting conservative exploitation rates as discussed in Section 10.1.2.1. Unlike the proposed project, there is no cap on quotas in the No Project Alternative. However, both the No Project Alternative and the proposed project will have similar and less than significant effects on predator populations due to the conservation measures in place to avoid excessive harvest of the Herring population.

Additionally, Herring are not the sole forage species for any of the predators (principally birds, fish and marine mammals) that utilize Herring for food. For predators that feed on Herring, a reduction in the SSB may lead to increases in effort of predators seeking out alternative sources of food or changing predator movement and behavior patterns. These impacts will be short-term, however, and are expected to be less than significant at the population level. Even though they should be less than significant, these impacts will be slightly greater than the proposed project due to the increase in fishing effort due to the higher number of permits and potential maximum quota.

10.2.2.3 Effects on Marine Habitats

As with the proposed project, gill nets are the only method used by commercial fisherman. Impacts to marine habitats from the No Project Alternative are likely to be greater than the proposed project due to the higher number of potential vessels operating and the larger maximum quota. These potential effects include anchor and net benthic scouring, subtidal disturbance to vegetation such as eelgrass, impacts to benthic infauna, and increased siltation from fishing vessel propeller wash. Due to the limited fishing season, the dynamic nature and ability of soft bottom infauna communities to recover quickly from disturbance, and that most eelgrass beds are closed to the Herring fishery, like the proposed project, the impacts to marine habitats should be limited and will likely be less than significant under this Alternative.

10.2.2.4 Effects on Non-target Species including Sensitive Species

The No Project Alternative would have similar effects on fish and invertebrate communities when compared to the proposed project, due to the use of the same fishing method (i.e., gill net). A number of associated species are accidentally taken during commercial Herring fishing operations (Section 5.9.1). However, the potential exists for any fish or invertebrate in the area to be taken. The species most likely to be taken are relatively small in size and more vulnerable to the mesh size used in Herring gill nets. Because of the very low levels of catch of non-target species, no significant short-term or long-term ecological effects are expected as a result of this rate of take with the No Project Alternative.

10.3 Alternative A: Harvest Guidelines Adjustment

Alternative A would set the HCR structured to have a minimum biomass estimate cutoff at 25,000 tons versus the 15,000 ton cutoff in the proposed project's HCR. Under the Alternative A HCR, in years where the SSB was estimated to be below 25,000 tons, no fishing would occur and the quota for the coming season would be zero. Above 25,000 tons, the target harvest rate would ramp up from 5% to 10% until the SSB reaches 40,000 tons. After that point, the quota would be capped at 4,000 tons.

10.3.1 Environmental impacts of Alternative A compared to proposed project (Summary)

Due to the higher cutoff in the HCR, Alternative A would likely increase the probability that the fishery would be closed more frequently, allowing the population some refuge from fishing pressure. One of the key performance metrics used in modeling a range of cutoff values was the probability of being above a critical low biomass threshold (defined as 10% of unfished biomass, or B0) in the last ten years of a 50 year simulation. Each of the HCRs analyzed with a 15,000 ton cutoff, as provided in the proposed project, had a 96% probability of being above 10% B0 in the last ten years. Whereas, the HCR with a 25,000 ton cutoff had a slightly higher probability being at or above 80% of Bmsy (defined as the biomass that would result in maximum sustainable yield, a commonly used target biomass in fisheries management) than the proposed project's HCR (64% versus 60% in the last ten years of the simulation). Alternative A had the lowest average catch and the highest variability in catch due to the high number of years that the stock biomass was below the cutoff, resulting in fishery closures 38% of the time (the highest closure rate for any HCR analyzed). Therefore, setting a higher cutoff threshold would provide for a more conservative approach to managing the fishing and Alternative A would potentially affect the environment less than the proposed project due to reduction in effort and catch on any given year.

10.3.2 Biological Effects

10.3.2.1 Effects to Herring Population

An analysis of the HCR performance using MSE was conducted for the 25,000 ton cutoff and this resulted in only marginal improvements in the projected SSB in the long term. Reducing effort and catch, an expected outcome of Alternative A, would be slightly more beneficial to the Herring population when compared to the proposed project, although the differences would be negligible as both Alternative A and the proposed project are not expected to cause any significant impacts on the Herring population as both quota systems are set at levels anticipated to allow recovery of stock if needed and buffer against future uncertainty due to environmental changes. Alternative A is not expected to have a significant effect on the Herring population.

10.3.2.2 Effects on Predator Populations

Alternative A would likely have less effect on predator populations than the proposed project due to the difference in effort and catch that could occur when compared to the proposed project. However, as with the proposed project, Alternative A is designed to ensure that fishing mortality does not negatively affect the stock’s role as forage and will not have any significant impacts on the predator populations in California.

10.3.2.3 Effects on Marine Habitats

Alternative A would likely have less effect on marine habitats due to the difference in effort and catch that could occur when compared to the proposed project. However, as with the proposed project, Alternative A is designed to ensure the Herring fishery does not negatively impact marine habitats and associated communities and will not have any significant impacts on marine habitats.

10.3.2.4 Effects on Non-Target and Sensitive Species

Alternative A would likely have less effect on non-target and sensitive species due to the difference in effort and catch that could occur when compared to the proposed project. However, as with the proposed project, Alternative A is designed to ensure the Herring fishery does not significantly affect non-target or sensitive species.

10.4 Alternative B: Round Haul Net Authorization and Permitting

Alternative B would allow an additional fishing method (gear) to be permitted for the commercial sector. The addition of round haul gear (purse seine and/or lampara) would be allowed as an option for fisherman that do not fish with gill nets. The permit program for round haul proposed under this project would be limited entry with a cap of five permits. The HCR would still dictate quota for the fishery, but the quota would be spit across the two sectors (gill net versus round haul) and based proportionately on the number of permits issued.

Round haul is a fishing gear that uses a large encircling net (Appendix G), which was eliminated in 1998 (Chapter 4). However, there have been informal requests in recent years from fisherman not participating in the gill net fleet to reinstitute round haul permits to facilitate fishing in San Francisco Bay for the fresh seafood market and for bait for sport anglers.

10.4.1 Environmental impacts compared to proposed project (summary)

Round haul, which consists of purse seine or lampara gear, was previously used in the fishery until 1994, when the Commission adopted regulations stating that all round haul permittees had five years to convert their permit to a gill net permit. At the time, the rationale behind this change was that round haul gear caught smaller, younger, lower value fish, and it was suspected that seiners increased mortality in the fishery by catching and releasing Herring during roe percentage testing. They are also more efficient than gill net gear and can take considerably more fish in a shorter time period. This can mean that Herring schools that spawn early in the season make up a disproportionate amount of the catch each year, and thus may contribute less spawning each year. Round haul gear is also less selective than gill nets and essentially wraps any fish that is encircled. However, catch from round haul nets also can be used as bait for sportfishing or sold in the fresh seafood market, neither of which require quality roe, or a specific sex or age class. This could provide an economic incentive to prevent waste that would exist if the fishery was operating only to harvest the roe. Depending on the time of the season the round haul nets operate, this Alternative, when compared to the proposed project, could have a greater negative effect on the environment, but possibly provide a better economic return to the few operators under the limited permitting system proposed.

10.4.2 Biological Effects

10.4.2.1 Effects to Herring Population

Alternative B would have similar effects on the Herring population as the proposed project in that the total catch via the HCR would not change, therefor leaving the conservative measures in place to allow recovery of stock, if needed, and also shield against uncertainty in environmental changes and influences, such as climate change. However, there are some differences between Alternative B and the proposed project that should be considered. Should round haul net operators choose to target fish for the roe market, then there could be an unquantifiable mortality of Herring due to the practice of wrapping and releasing of inferior-quality roe Herring by round haul vessels. This practice of "high grading" occurs when less desirable fish due to small size or low roe count is discarded to retain higher-value fish and stay within the catch allocation for the year. While this could be mitigated through regulations, past practices have shown that these types of regulations are difficult to enforce.

When compared to gill nets, round haul nets are also less selective, regardless of the which market the fish are sold to (roe, bait, or fresh). Removing younger fish (one and two year olds) from the population is far more likely with Alternative B than the proposed project, which primarily target older fish (three, four, and five year olds). Removing younger age classes from the population negatively effects recruitment which in turn could reduce future populations by decreasing the available spawning biomass on any given year. Given the wrap and release mortality concerns and the ability to capture more age classes, Alternative B would result in impacts to the Herring population that are greater than the proposed project.

10.4.2.2 Effects on Predator Populations

Should round haul nets negatively affect recruitment as described in Section 10.3.2.1, then Alternative B could have a greater impact on predator populations than the proposed project by reducing the amount of fish available for food or to spawn and reducing the number of other forage fish through bycatch. However, conservative quotas will limit the effects to both the Herring population and that of any bycatch species taken. Due to this, Alternative B may not negatively affect the stock's role as forage and will not have any significant effects on the predator populations in California.

10.4.2.3 Effects on Marine Habitats

Adding round haul nets as an additional method would likely not impact marine habitats, because round haul nets do not set anchors. There may be occasions when the lead line of the net drags along the bottom, which could lead to vegetation scouring and siltation as described in the proposed project (Section 10.1.2.3). Benthic infauna communities are not likely to be disturbed as lead lines, unlike anchors, are unlikely to dig deep into the benthos. Therefore, Alternative B would have less than significant effects on the marine habitat and cause slightly less impact than the proposed project.

10.4.2.4 Effects on Non-Target and Sensitive Species

Gear selectivity plays an important part in the amount of incidental catch that occurs in any given fishery. Round haul nets have the possibility of having more discarded catch from bycatch and low value age classes. Sensitive species such as salmon, Steelhead, Longfin Smelt, *Spirinchus thaleichthys*, and

Green Sturgeon, *Acipenser medirostris,* all have the potential to be captured by round haul nets. While fisherman would be prohibited from retaining these fish, there is uncertainty regarding post release mortality rates. When compared to the proposed project, due to the less selective nature of round haul nets, impacts to non-target and sensitive species are likely to be greater with Alternative B. However, due to the short season of the fishery (January through mid-March) and the low number of vessel permits proposed for this Alternative (five), the overall impact to non-target and sensitive species is likely to be less than significant.

10.5 Alternatives Considered but Not Carried Forward

10.5.1 A Recreational Bag Limit of 100 Pounds

In soliciting public comment on the proposed management strategy in the Herring FMP, many recreational participants responded that a 50 pound daily bag limit (one 5 gallon bucket) was sufficient to meet their needs, there were some recreational participants who felt that this amount of catch was too limiting because there are so few spawns during the year that are close enough to a public pier or beach where it is accessible to recreational participants. Some participants commented that they share Herring with family members and would like to see a higher bag limit of 100 pounds (two 5 gallon buckets) to facilitate this. While it is true that not all spawning events are accessible to recreational fishermen, those that are have experienced very intense fishing pressure, with reports of hundreds of fishermen on piers, jetties and in the intertidal zone, fishing with hook and line or cast nets, therefore the recreational fishing pressure on some spawning events may be significant. This alternative is not being analyzed as it is the Department's goal to protect the sustainability of the resource while maintaining a satisfying recreational experience and based on feedback this can likely be achieved with a bag limit of 50 pounds.

10.5.2 Alternative Fishing Methods

During the public scoping and public comment periods of the Herring FMP, the Herring FMP Project Management Consultant Team received a few requests to consider allowing the use of alternative gear types to take Herring. Round haul nets were evaluated as Alternative B above, although there were requests to consider other types of gear, including cast nets. Cast net gear have been discussed because stakeholders have expressed an interest in facilitating a fresh fish fishery for a local market and feel these gears would allow for smaller catches of higher quality fish necessary to fulfill fresh fish market orders, which could evolve into a lucrative market for Herring. However, since this gear has not been used in the commercial fishery previously, leading to a lack of data to analyze, the best venue for considering and evaluating these gears would be through an Experimental Fishing Permit (FGC §1022). Future consideration of these gears could occur within this FMP after an Experimental Fishing Permit for each gear type has been issued and subsequent reports have been filed with the Department.

10.6 Summary of Alternatives Analyzed

Proposed alternatives for management of the Herring fishery have been analyzed in this chapter. A comparison of these alternatives and their effects on the objectives of the Herring FMP enables identification of which alternatives would best meet management needs.

Although each of the alternatives has some benefits for management, only Alternative B addresses most of the objectives of the Herring FMP and MLMA (Table 10-1). Alternative B could provide more economic benefit but would also introduce more risk to the environment and could potentially create competition and develop conflict between the two permitting sectors (gill net versus round haul). The No Project Alternative would also not achieve all the goals outlined in the FMP and the lessons learned from the existing regulations constituting this Alternative were the impetus for the proposed project.

Table 10-1. Alternative analysis matrix.				
Goals Met (y/n)	Proposed Project (Preferred)	No Project Alternative	Alternative A	Alternative B
Includes species and fishery related background information	Yes	Yes	Yes	Yes
Includes industry and public's perspective	Yes	Yes	Yes	Yes
Identifies relevant ecosystem indicators	Yes	No	Yes	Yes
Provides adaptive management framework	Yes	No	Yes	Yes
Contains criteria to limit overfishing	Yes	No	Yes	Yes
Creates an efficient permitting system	Yes	No	Yes	Maybe
Uses collaborative fisheries for research	Yes	Yes	Yes	Yes
Minimizes risk to habitats from fishing	Yes	Yes	Yes	Yes
Minimizes bycatch to extent practical	Yes	Yes	Yes	No
Promote a healthy long-term average biomass	Yes	Yes	Yes	No
Minimize the number of years stocks are in a depressed state	Yes	Yes	Yes	No
Maintain a healthy age structure	Yes	Yes	Yes	No
Maintain an economically viable fishery	Yes	Yes	No	Yes
Ensure Herring remain an important component of the ecosystem	Yes	Yes	Yes	Yes

10.7 Environmentally Superior Alternative

CEQA requires a lead agency to identify the "environmentally superior alternative". The environmentally superior alternative would be Alternative A, due to the higher cap set for the HCR which would potentially reduce the overall effort and catch of the fishery due to a higher frequency of seasonal closures from not achieving the 25,000 ton SSB threshold to open the fishery. The lack of a fishery from year to year could have positive effects on the Herring populations and predator interactions. This could also ameliorate any impacts to marine habitats by providing larger recovery times in between seasonal closures. However, Alternative A does not meet the objectives of producing a year-to-year stable fishery and the relatively modest gains in terms of meeting the biomass target and avoiding the biomass limit were deemed by the SC to be not worth an average catch that was 30% lower, a higher variability in year to year catch, and a fishery closure rate that was almost double that of the agreed upon HCR. Due to this, the proposed project is still the preferred project as it meets all the core program objectives while also not significantly effecting the environment.

10.8 Mitigation Measures

Fishing activities will result in the removal of a small proportion of Herring from the population. However, specific safeguards included in this Herring FMP such as management based on a conservative harvest control rule, designed to ensure that removal of those fish will not exceed sustainable levels, reduction in the number of permitted vessels, an adaptive management framework, the use of ecological indicators to buffer against environmental uncertainty, while including industry and public support which should lead to greater compliance with regulations. These provisions allow for the conservation of Herring in California waters. Since no significant negative effect of this proposed project is expected on the Herring population, and no significant effects on the environment overall, mitigation measures are not being provided.

Appendix A Sources and Estimated Rates of Natural Mortality for Pacific Herring

Review of Natural Mortality in Pacific Herring at Each Life Stage

Sources and annual rates of natural mortality for Pacific Herring (Herring), *Clupea pallasii*. differ at various life stages, with mortality typically being greatest during the first year of life. Egg mortality is high, with estimates ranging from 55 to 76 percent (%) (Norcross and Brown, 2001; Rooper and others, 1999) up to 100% (Tester, 1942). Possible causes of egg mortality include wave action, predation, smothering by dense egg deposits, hypoxia, desiccation, air-water temperature differentials, and microorganism invasions (Alderdice and Hourston, 1985; Carls and others, 2008a; Hay, 1985; Norcross and Brown, 2001). Survival of eggs is highly variable from year to year, and thus a large spawning event does not necessarily correlate with a strong year class (Watters and others, 2004).

Mortality of larvae soon after hatching (posthatch) can be caused by starvation due to physiological abnormalities such as underdeveloped jaws, resulting from exposure to unusually warm air temperatures (Norcross and Brown, 2001; Purcell and Grover, 1990). Posthatch mortality appears to vary geographically and interannually, and ranges from 0 to 50% (Norcross and Brown, 2001). Model results indicate that larval mortality increases between 93 and 99% during the dispersal period when larvae are transported from spawning sites to (either favorable or unfavorable) nursery areas (Norcross and Brown, 2001). Between 18 and 36% of larvae may starve during this time (McGurk, 1984). The other major cause of larval mortality is predation by a wide range of organisms (Norcross and Brown, 2001; Purcell and Grover, 1990). As larvae must find suitable, exogenous food during this period, larval survival is likely the major determinant of year class strength (Carls and others, 2008a; Norcross and others, 2001).

Rates and sources of mortality for juvenile Herring depend on the time of year. Estimated mortality of juveniles in Prince William Sound, Alaska, ranges from 79 to 98% from August to October and 1 to 96% during the winter (Norcross and Brown, 2001). From August to October, juvenile Herring survival depends mainly on food availability, competition, predation, and disease (Norcross and Brown, 2001). Juveniles may begin to school during this time to minimize the risks associated with the food availability, competition and predation (Carls and others, 2008b). During the winter season, survival of 1 year (yr) old Herring depends on the conditions in the areas where these fish overwinter (Norcross (Carls and others, 2008b; Norcross and Brown, 2001).

Typical mortality rates for adult Herring worldwide are between 30 and 40% (Stick and others, 2014), though higher (and increasing) mortality rates have been documented in some Herring stocks. For instance, estimates of annual mortality rates for Herring stocks in Washington have increased from less than 40% in the late 1970s to over 60% in the early 1990s (Bargmann, 1998; Gustafson and others, 2006). Natural mortality of adult Herring may be due to predation, disease, starvation, interspecific competition, or senescence, and observed increases in mortality could also be caused by pollution or climatic shifts (Carls and others, 2008a; Stick and others, 2014).

Estimated Survivorship to Maturity

Using the above reported minimum average observed mortality rates for Herring at each life stage (egg, post hatch, larval, juvenile, and 1 yr old Herring) in areas north of California, the percentage of eggs surviving to maturity (at age two or three) is very small (<0.004%) with fewer than four eggs out of every thousand laid reaching maturity. In San Francisco Bay, for the 2003-04 to 2014-15 year classes, survival from egg to mature Herring (3 yr) ranged from a low of 0.0001% to a high of 0.0781% and averaged 0.0125% (Greiner, in preparation) (Figure 1). Survival to maturity in all Herring stocks is highly variable and while the average egg laid in a given year may have a very low probability of survival, a single spawning event may contribute disproportionately to the surviving year class because of favorable environmental conditions at the time and location of spawning.

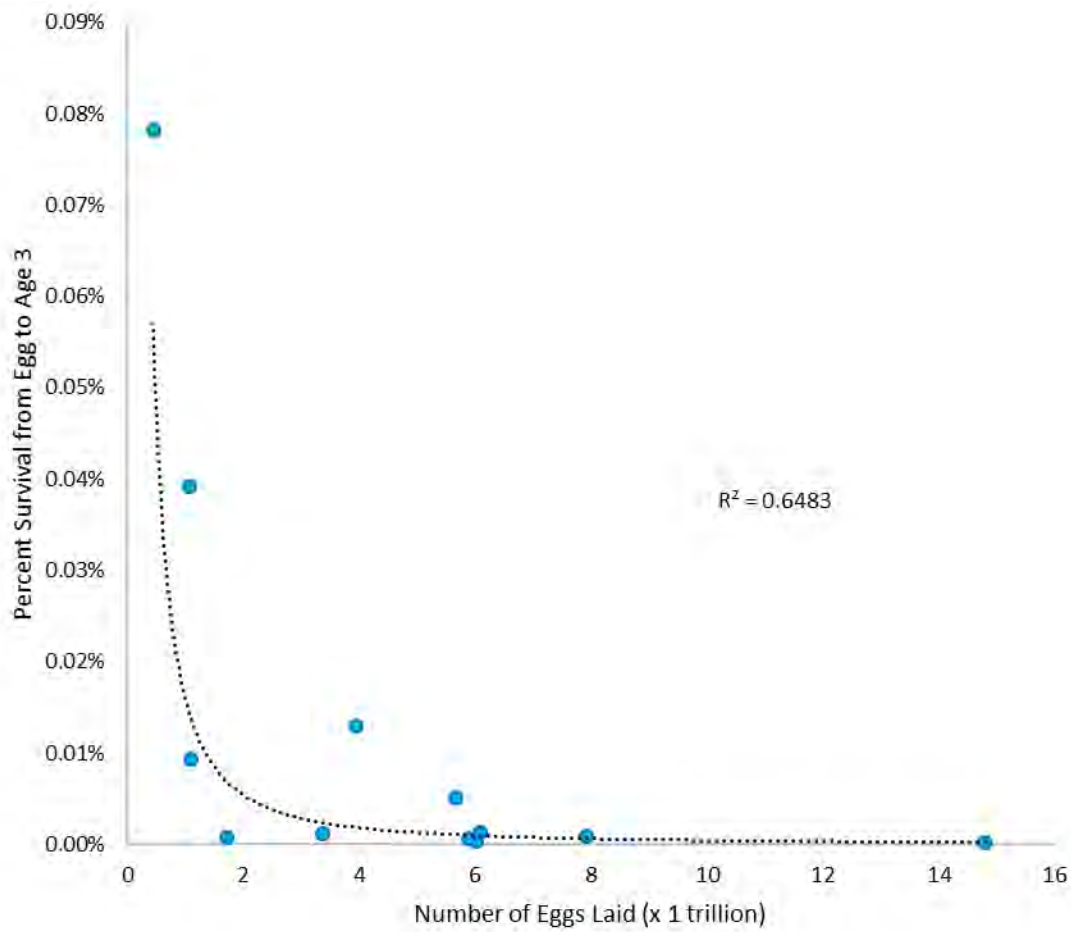

Figure 1. Number of eggs laid (times one trillion) in San Francisco Bay from 2003-04 through 2014-15 and the percent survival of that cohort to age-3. Calculations used for number of eggs spawned and survival from egg to age-3. The number of eggs spawned each season was calculated by multiplying the spawning escapement (short tons) by 102,511,876, which is the number of eggs per short ton of fish (50:50 sex ratio by weight assumed and fecundity of 113 eggs per gram of male and female fish which was multiplied by 907,184.74 grams per short ton). The numbers of age-3 fish in the cohort were taken from the tonnage and number at age spreadsheets produced annually. The number of eggs spawned was divided by to the number of age-3 fish three years later to calculate survival.

Appendix B Cefas Stock Assessment Model Report and Peer Review Response

California Department of Fish and Wildlife Response to Stock Assessment Peer Review for the Pacific Herring Population in San Francisco Bay September 2017

In 2011, with funding provided by the San Francisco Bay Herring Research Association, the Department of Fish and Wildlife (Department) contracted with scientists at the Center for Environment, Fisheries, and Aquatic Science (Cefas) to develop a stock assessment model for the Pacific herring (*Clupea pallasii*) population in San Francisco Bay. The purpose of this work was to develop and fit a population to all available data in order to estimate the status of the San Francisco Bay herring stock. This stock assessment would then form the basis for an operating model that could be used to evaluate the expected impacts of various management decisions going forward as part of a Management Strategy Evaluation (MSE) framework. It was anticipated that this analysis would be used in developing a Harvest Control Rule (HCR) as part of an adaptive management approach during development of a Fishery Management Plan (FMP) for the Pacific herring fishery.

Following the stock assessment peer review, the reviewers concluded that they could not recommend its use as a method for estimating biomass and setting quotas for the commercial herring fishery. This was primarily because the model that best fits the available data (the preferred model) does not reflect current understanding of herring stock dynamics. The modeling exercise and review highlighted the level of uncertainty about the dynamics of the San Francisco Bay stock and the inability to base management decisions on any single model. The reviewers emphasized the following areas of concern with the Cefas model and associated data:

- Inability to establish a defensible stock recruitment relationship
- Lack of empirical support for various mortality factors used
- Unresolved issues related to gear selectivity at age
- Over-weighting of age composition data inputs relative to young-of-year-based recruitment and spawn deposition-based spawning stock biomass indices

The reviewers also recommended that the model not be used as the base model for the MSE analysis, but as one of a number of uncertainty scenarios. The Department accepts the recommendations of the review panel and agrees that the deficiencies in the Cefas model, identified above, could lead to the overexploitation of the herring stock if adopted as a management tool. Instead, the Department is following the review panel's recommendation and using Cefas's preferred model (Model 6) as one of a range of operating models representing alternative hypotheses of how the stock functions as part of an MSE.

The results of Cefas model development and review, as well as the discussions between Department biologists, the review panel and Cefas scientists, have provided valuable insight into San Francisco Bay population dynamics. They have also helped identify which areas still represent major uncertainties, which will ultimately inform the MSE work for testing Harvest Control Rules (HCR). In the interim, based on the peer review recommendation, the Department will continue to use spawn deposition surveys to set quotas, and will be exploring candidate HCRs based on this method using MSE. These steps will help to ensure that the harvest strategy chosen through the FMP process will be robust to uncertainties and continue to provide a sustainable Pacific herring fishery in San Francisco Bay.

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Review of the Stock Assessment for the Pacific Herring Fishery in San Francisco Bay

October 10th and 11th, 2016

Peer Review Panel Members:

Harold J. Geiger (chair)
St. Hubert Research Group
Juneau, Alaska

Jake Schweigert and Nathan Taylor
Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, B.C.

Background

On October 10th and 11th, the California Department of Fish and Wildlife organized a peer review of the recently completed stock assessment of San Francisco Bay Pacific herring. A peer review panel consisting of Jake Schweigert and Nathan Taylor of Fisheries and Oceans Canada in Nanaimo, B.C., and Hal Geiger of the St. Hubert Research Group in Juneau, Alaska traveled to Santa Rosa California to meet with modeler Jose De Oliverira from Cefas in the United Kingdom. Also participating were Kirsten Ramey, Ryan Bartling, Tom Barnes, Tom Greiner, and Andrew Weltz of the California Department of Fish and Wildlife, and Sarah Valencia, a consultant hired to develop the management plan for the fishery. The review panel, chaired by Hal Geiger, was given the following objectives: (1) review and discuss the stock assessment and operating models for San Francisco Bay Pacific herring, (2) provide recommendations to the stock assessment modeler for any changes to the assessment, (3) determine whether the final product is appropriate and sufficient for use in management of the Pacific herring fishery in San Francisco Bay via incorporation into the Fishery Management Plan, and (4) provide a written panel report to the Department of Fish and Wildlife.

Prior to the meeting in Santa Rosa, the review panel received a written report (San Francisco Bay Herring: Stock Assessment and evaluation of Harvest Control Rules, by Roel et al., March 2016 version), which formed the basis for most of the review. The panel evaluated the technical merits of the approach, but in the broader context of the management strategy evaluation approach (Punt et al. 2014) described in the Roel et al. report, the panel considered whether any new approach would result in improved fishery outcomes. The panel endorses, in principle, the management strategy evaluation approach for analyzing the effect of alternative management strategy choices. As an analytical instrument, the management strategy evaluation provides a process for evaluating and presenting trade-offs between alternative management strategies (i.e. the choices of data, assessment model, and harvest control rule).

Comments Related to the Data Used for the Analysis

At the review meeting, the panel was surprised that the modeling appeared to have been conducted with an incomplete and undocumented data set. The panel recommends that prior to further modeling of the San Francisco Bay Herring population, all data required for model development should be fully reviewed, and that the final data set include all necessary measurements and metrics. If there are any instances where specific years or components of a data series are excluded, then this should be fully explained in a revised report. A process should also be set up to ensure that only a single quality-assured, complete data set is adopted for modeling at a given time. This data set should be maintained for subsequent analyses, and updates or revisions should be tracked by a version-control or report number.

The decision to restrict the analysis of the San Francisco Bay herring population to the years 1992 to 2013 requires further comment and justification in view of the existence of additional earlier data. The data series that was analyzed reflects a period of reduced harvest levels. The reduced harvest provides limited contrast in the data, which constrains the ability to estimate some model parameters. Moreover, by not using a longer time series of data the model relies on assumptions of the depletion level at the beginning of the modeling period.

A description of the process used to acquire age-composition data and its application to the derivation of catch at age for the commercial and research surveys is needed in a revised report. A reviewer attempting to understand the unique problems and issues with the input data, such as the sample sizes, measurement error, non-sampling error, or similar issues, can only find statements as brief as this one from page 3: "Input data for the assessment were provided by Tomas Greiner, California Department of fish (sic) and Wildlife," or "A recruitment index was derived from the Young of the Year surveys."

The panel noted the mention of a herring eggs on kelp (HEOK) fishery in the overview on the San Francisco Bay Pacific herring spawning stock and commercial fishery management. However, no information on the landings from the fishery or information on its relative significance was provided in the Roel et al. report. This should be addressed in a revised report. It was not possible for the panel to assess the impact of this herring removal on the stock assessment.

Comments Related to the Age-Structured Model

The panel agreed that the description of the assessment model in the Roel et al. report was inadequate to allow for complete and thorough review. Additionally, as an aid to review, the panel recommends that a revised report include appendices detailing all parameter estimates for each model run and that additional model runs be included to demonstrate the robustness of the results to varying assumptions and model building decisions.

The panel found the decision to adopt the hockey-stick stock-recruit function equivocal and not well supported by data. Moreover, the implications of this choice were not clearly communicated to the reader. The available data are insufficient to demonstrate the relationship between stock size and subsequent recruitment, especially for small stock sizes. The choice of the hockey-stick model results in predictions of unrealistic resilience in the population dynamics, especially at high levels of fishing mortality.

The formulations chosen for gear selectivity were confusing and do not adequately reflect what is known about herring biology. The selectivity ogives for the commercial fishery indicated a broad range for round-haul nets and a domed pattern for gillnets (Figure 4 in the Roel et al. report), the latter peaking at about 185 mm corresponding to age-4 herring, a pattern that is consistent with the selectivity of the research trawls shown in Figure 11. However, the selectivity function in the model adopts full selection by the fishery (gillnets since 1998–1999) at age 5 and 6+. The panel agreed that further explanation of these decisions is required.

The final operating model[1] developed for the evaluation of harvest control rules implements a sequential approach to the inclusion of flat topped commercial selectivity, a 2007 natural mortality event associated with the oil spill, a fixed natural mortality and mortality multiplier to age 6 and older herring (Table 4 in the Roel et al. report). However, the explanation for the

[1] The term *operating model* is used here to mean an overall model to simulate various management outcomes based on models of the stock dynamics, the management, and the data acquisition.

choice of this version of the model is unconvincing and the mortality multiplier for age 6+ seems ad hoc and arbitrary. It would be helpful to repeat the runs described in Table 4 of the Roel et al. report for all cases with natural mortality fixed at 0.53 as in the final run. The analysts might also consider testing a linear function for mortality from age 3 when fish are fully mature to age 6+. Such an approach could be more readily justified on a biological basis.

Decisions about model selection in this report rely heavily on the total likelihood, the largest component of which relates to the fit of the age-composition data. Table A1.3 in the Roel et al. report presents the catch at age for the commercial fishery and Table A1.5 presents the catch at age for the research survey. The research catch-at-age data presented in this version of the report is an order of magnitude larger than the commercial catch at age. This seems implausible. These data also do not reflect the exceptional 2002 or 2003 year classes that produced the large 2005 spawning stock biomass. As we discuss above, the panel again recommends that these data be carefully reviewed and fully documented before conducting further modeling.

The panel also noted that Figure 7 of the Roel et al. report shows an inability of the model to adequately explain the spawning stock biomass index from 2009 to 2013. This result requires further analysis and comment in a revised report. Similarly, no explanation is provided for the positive trend in recruitment residuals (Figure 9 of the Roel et al. report). Some of these residual patterns are symptomatic of poor goodness of fit to the data and the reasons underlying this pattern need to explored and preferably rectified.

Provided that a defensible operating model can be developed, the panel identified several deficiencies in the way the model described in the Roel et al. report simulated herring population dynamics. In particular, the analysis must include more challenging scenarios with which to test the alternative management procedures. In the Roel et al. report, the scenarios involved routine sampling from well-behaved probability distributions that were expected to reproduce historical conditions over a short time scale. Dynamic species like herring have both variable recruitment and variable natural mortality (as environmental conditions change). More challenging scenarios should include periodic el Nino, infrequent catastrophic events, climate change, induced changes in recruitment, or changes in natural mortality, for example. In addition, the analysis would benefit greatly by imbedding the assessment model into future simulations in order to capture assessment model estimation errors that can be very large (Punt et al. 2014). Failing to consider such factors results in an under-estimation of the uncertainty in the range of future outcomes for the stock and the fishery under a given management strategy. That would mean quantities like the probability of breaching a limit reference point could be much higher in reality than what would have been demonstrated in the simulations.

The panel agreed that a broader range of performance statistics is needed to increase the relevance of the work for decision making. Some of these statistics could be quantities such as the probability of being at a target biomass for the stock, the probability of fisheries closures, and the average annual variability in the catch. Moreover, the presentation would benefit from having the performance statistics partitioned into more time frames. The time horizon for achieving particular objectives or avoiding limits may be particularly important. For example, the application of any particular management strategy may have consequences that are undesirable in the short term (5–10 years) even if in the longer term (over 20 years) performance is good. Performance statistics used in other management strategy evaluations might be useful for application in future analyses (see Taylor et al. 2014, Schweigert et al. 2007, for examples).

Suggested Revisions to a Final Report

The version of the report the panel received appeared incomplete, contained insufficient material and detail for a full and complete review, and the document contained obvious errors that left the panel wondering about errors that were not as obvious. The panel suggests that the main document be rewritten in the standard Introduction-Methods-Results-Discussion format of a scientific report. Each section should be written in sufficient detail to allow a reader not already fully familiar with the subject to understand and be able to critique the analysis.

The Introduction should introduce the reader to the history of the fishery, the history of the management process, and explain how the results of the current analysis and modeling would provide a basis for altering existing management approaches. Importantly, the Introduction should specifically lay out the goals and intent for management and for the study. This context is essential for understanding the decisions about the parameterization of the assessment model and also for understanding the relevance of the management strategy evaluation analysis.

The Methods should contain a complete review of the all data sources (see the section on Comments Related to the Data Used for the Analysis, above). As previously mentioned, this review should allow the reader to understand how far back in time the data series goes, understand the sampling design for the survey index, understand the protocols for the ageing data, understand the sampling design for the commercial age-composition data, understand what data exist from prior to 1992 and why these data were not used, and so forth. Additionally, the Methods should fully introduce the models. The revised report should contain descriptions relating to the choice of the stock-recruitment function, gear selectivity, natural mortality, and the maturity ogive. The Methods should cite authorities, describe where the models came from, and include a narrative that introduces notation and describes the parameters to readers not familiar with the models. This section should tell the readers how the state dynamics are updated at each time step, how the subsequent model fitting procedure occurs (including choice of likelihood function formulation), and so on. In summary, this section should contain sufficient detail for a reader to be able to reproduce the analysis after reference to materials in any appendices.

In the Roel et al. report, the material relating to the methods appears to have been written for someone already fully familiar with the model. In other words, this material appears to have been written for someone that only needs brief reminders of model notation rather than a presentation introducing the material for the first time. A section of the document found under the heading of "Assessment Model" contains a few facts about the model, but no explanation of model development or any of the theory underpinning the model. The reader is incorrectly referred to Appendix 1 of the Roel et al. report for a "generic description of the model."

Appendix 1 contains tables of input data; Appendix 2 does contain over five pages of lists of equations—not a "generic description of the model." The equations in Appendix 2 were introduced without explanation, and equations in Appendix 2 appear before the notation is introduced to the reader.

When the reader does discover Appendix 3 in the report, the reader finds only brief reminders of the meaning of the notation. For example, the notation *F* is commonly used in age-structured models in North America to mean the instantaneous fishing mortality. In Appendix 3, $F_{y,a}$ is defined as fishing mortality at age a in year *y*. This brief comment fails to clearly tell the reader that *F* is being used to denote a kind of harvest rate. The reader is left to see by inspection of equation A2.1 that if *F* indicates instantaneous mortality then this equation does not make sense. Similarly, C_y^f is described as "Catch of fleet *f* in year *y*." To fully understand the meaning of this notation in equation A2.3 the reader will need to correctly guess that *C* is in units of weight or mass or else carefully inspect the units of the other quantities in equations that contain *C* so as to infer the appropriate units. In North America *C* is often used to denote catch in units of individual fish. Some of the equations may contain errors, but the panel was unable to decode the notation, infer the meaning of the equations, and check the equations in Appendix 2 carefully in the time available. Some narrative walking the reader through the equations should be considered essential in a revised report.

The Results section should lead the reader through the results in a logical manner so that the reader will be able to understand and digest the material in the figures and tables. In most cases, the tables and figures in the version of the report that the panel was given were insufficient for their intended purpose. Most graphics were too small and many had unlabeled axes. Table captions did not describe the table contents adequately. Graphics and tables were usually introduced without any kind of interpretation or context (e.g., "Model fits to the SSB and recruitment indices are shown in Figure 7."). Figure 6 in the Roel et al. report is described in the figure caption as a "Likelihood profile," yet the preferred estimate is shown at some kind of minimum—not the maximum. In this case there is an axis label, but that axis is described with the nonspecific term "Function value." The reader is left to decide whether the figure caption is wrong and "Function value" means the negative log likelihood rather than likelihood, decide whether this is simply the entirely incorrect figure that was included by mistake, or whether something else happened. All of the figures should be reviewed and brought up to the standards that are usually required for a scientific publication. In contrast, note that Figure 12 in the report provides a good example of a helpful graphic. Here the axis labels and the figure caption complement each other. The figure works to allow the reader to understand a complex point about the model fitting that is important to understand the limits of the model's ability to predict.

The panel was surprised to find that the report they reviewed contained essentially no discussion of the important implications for the use of the estimated model in fishery management. This important section of the report should be a place where the model results are placed in context for the reader, a place for synthesis and integration of new information with historical information, and a place where uncertainty and limitations are carefully explained to the reader. A carefully constructed Discussion in the report is the place to try and communicate these limitations to the fishery management, the fishing industry, and other concerned organizations and individuals.

Much more importantly, there is no discussion of the important conflict between predicted yield based on the proposed model and the actual fishery performance in the past. The panel noted that the proposed model predicts that yield will increase as the harvest rate increases from 0.0 all the way to 1.0 (Table 6 and Figure 15 in the Roel et al. report). This result is both surprising and counter-intuitive. Additionally, this result also serves to demonstrate how new models can create a potential liability for management's credibility if the management has not carefully validated the model.

In contrast to the prediction that very high harvest rates are sustainable, the panel that conducted the 2003 review of San Francisco Bay herring (see Appendix A attached to this review) concluded that harvest rates at that time had been too high and were not sustainable. The 2003 panel specifically stated the following: "The current harvest strategy for this stock should be re-evaluated and explicitly documented. The current harvest rate policy of 20% appears to be too aggressive under current levels of stock production. A harvest rate in the range of 10–15% appears to be sustainable with the lower level providing a desirable target for stock rebuilding." The Roel at al. model's prediction that a 100% harvest of the available population in the future would be sustainable and the observation that a 20% harvest in the past had been considered excessive obviously needs to be brought out in a Discussion and reconciled.

There were 10 paragraphs in the Conclusions. Some of these conclusions appeared to be correct but not supported by evidence found in the report (e.g., see the first paragraph in the Conclusions). The panel also questioned whether other statements were correct or not. Either way, the team agreed this section should be revised, expanded, or combined with a new Discussion section.

Final Comments and Recommendations

Before a management agency adopts a complex model into its management strategy, the agency should have a clear understanding of how the model is going to be used. The agency should also have given adequate thought to the consequences of assumptions and choices in model development that might simply be wrong. These considerations should affect any future review.

An age-structured model could be used either to study the effects of various management actions or strategies (i.e., the management strategy evaluation), or the model could be used for short-term decision making, such as setting a total allowable catch. These two uses are not the same. For example, a model of herring dynamics might be quite useful and safe as a way to combine fishery-derived information with fishery-independent information so as to smooth out random fluctuations in a spawn deposition survey to set harvest rates when fishing mortality is low. Yet, this same model may completely fail to predict the stock dynamics at very high fishing mortality—especially when the model is used to predict what will happen far outside the range of the data that was used to construct the model.

Roel et al. cite "Punt et al. (*in press*)" (this should now be cited at Punt et al. (2014), which is how we have cited it) as a key reference on the management strategy evaluation (MSE) approach. Punt et al. stress, "The ability of MSE to facilitate fisheries management achieving its aims depends on how well uncertainty is represented, and how effectively the results of simulations are summarized and presented to the decision-makers." In other words, it is not good enough to simply have an operating model, assessment model, and a set of closed loop simulations. A complete management strategy evaluation involves a careful study of uncertainty—including a careful analysis of "what if we are wrong." At a minimum the assessment must address this question: what if the population dynamics in nature are different from those assumed in the assessment? There are many layers of uncertainty involved in modeling herring dynamics, including uncertainty as a result of a random and possibly changing environment, uncertainty due to estimation and sampling error, uncertainty that could be the result of incorrect assumption or modeling decisions. Prior to further review, the analysis needs a much more sophisticated study of uncertainty. The panel agrees that the cited Punt et al. article could be used as a guide.

The panel recommends that the California Department of Fish and Wildlife at least consider some simpler, more cost effective management tools. Age-structured assessment models can be demanding in terms of both data and in the capacity to use these tools. The capacities to run, update, and explain such models within the agency may be limited, expensive, and may divert resources way from more important needs. In some cases adopting the age-structured modeling approach for annual decision-making may even erode fishery outcomes if the effects of the models are not well understood or if the models poorly predict the dynamics of the population. Many alternative assessment models or management based on smoothed survey estimates could be less costly and potentially more effective. For example, Kalman filtering (Walters 2004) has been evaluated in other herring fisheries (Cleary et al. 2010). Even with these simpler tools in place to set catch limits, management strategy evaluation simulations could be used to illustrate how these alternative models perform in terms of catch, variability and conservation metrics with similar or different harvest control rules. It may be possible to show with a more complete accounting of uncertainty that a harvest control rule based on the annual survey could have a similar, or even better, performance without the cost and complexity of adopting an annual age-structured modeling calculation and evaluation.

In anticipation of future modeling in support of management strategy evaluation, the panel recommends that California Department of Fisheries and Wildlife engage with stakeholders to develop objectives and performance indicators for the management of the fishery. The single factor of breaching the precautionary limit biomass, or the putative limit reference point, with greater than 5% probability, examined in the Roel et al. report, is unlikely to universally satisfy the larger community. For example, the panel heard during the review that some individuals and organizations might be concerned about addressing the broader ecosystem consequences of the fishery on a forage fish like herring. In this case, the metrics identified in some of the forage fish literature (Essington et al. 2015, Smith et al. 2011) may be very important.

Additionally, management strategy evaluations (Hall et al. 1988 for a herring-specific example) have documented that the objectives typically trade off against each other. For example, high average catches occur at the expense of high variability in catch. By failing to consider a broader set of objectives it is not possible to understand the broader set of consequences of applying a given management strategy on the industry, the stock, or the ecosystem.

Given the concerns about aspects of the development of the operating model based on the relatively short time series and outstanding questions about the data and the ability of such a model to reasonably predict the future productivity and resilience of the San Francisco Bay herring population given climate warming and unpredictable catastrophic events, the panel cannot endorse the model described in the Roel et al. report for the development of harvest control rules and reference points at this time.

As a concluding recommendation, the panel again recommends that the California Department of Fish and Wildlife adopt a stronger policy of documentation. Details of each year's surveys and monitoring should be recorded and archived at least in timely internal reports.

Finally, the panel strongly commends the professionalism of the California Department of Fisheries and Wildlife staff. Their dedication to the annual collection of herring assessment data, given their limited resources, is indicative of their vision and commitment. This herring assessment data provides the basis for any rigorous statistical analyses, the modeling effort reviewed here, or any kind of rational management.

Acknowledgement

The panel thanks Jose De Oliveira for his patient help explaining the model, for conducting additional simulations for the panel, and for all his help in the review. We also thank Andrew Weltz and Tom Greiner for their help in understanding the history of spawning survey and the management. We thank Tom Barnes, Ryan Bartling, and Kirsten Ramey for organizing the review and for their warm hospitality while we were in Santa Rosa.

Literature Cited in the Review

Cleary, J. S., S. P. Cox, and J. F. Schweigert. 2010. Performance evaluation of harvest control rules for Pacific herring management in British Columbia, Canada. *ICES Journal of Marine Science* 67:2005-2011.

Essington, T. E., P. E. Moriarty, H. E. Froehlich, E. E. Hodgson, L. E. Koehn, K. L. Oken, M. C. Siple, and C. C. Stawitz. 2015. Fishing amplifies forage fish population collapses. *Proceedings of the National Academy of Sciences* 112:6648-6652.

Hall, D. L., R. Hilborn, M. Stocker, and C. J. Walters. 1988. Alternative harvest strategies for Pacific herring (*Clupea harengus pallasi). Canadian Journal of Fisheries and Aquatic Sciences* 45:888-897.

Punt, A. E., Butterworth, D. S., Moor, C. L., De Oliveira, J. A., and Haddon, M. 2014. Management strategy evaluation: best practices. *Fish and Fisheries*: 3-32.

Roel, B.A., N.D. Walker, and J.A.A. De Oliveira. 2016. San Francisco Bay Herring, Stock Assessment and evaluation of harvest control rules. Draft Manuscript prepared by Cefas for the peer review. 43 p.

Schweigert, J.F., Fu, C., Wood, C.C., and T.W. Therriault. 2007. A risk assessment framework for Pacific herring stocks in British Columbia. *Canadian Science Advisory Secretariat Research Document* 2007/047: 78p.

Smith, A. D. M., C. J. Brown, C. M. Bulman, E. A. Fulton, P. Johnson, I. C. Kaplan, H. Lozano-Montes, S. Mackinson, M. Marzloff, L. J. Shannon, Y.-J. Shin, and J. Tam. 2011. Impacts of Fishing Low–Trophic Level Species on Marine Ecosystems. *Science* 333:1147-1150.

Taylor, N.G., Hicks, A.E., Grandin, C. Taylor, I.J. and Cox, S.P. 2014. Status of Pacific Hake (Whiting) stock in U.S. and Canadian waters in 2013 with a management strategy evaluation. *International Joint Technical Committee for Pacific Hake*. 196p.

Walters, C. J. 2004. Simple representation of the dynamics of biomass error propagation for stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences* 61:1061-1065.

This document provides brief responses, where appropriate, to some of the comments from the reviewers.

Responses by José A.A. De Oliveira and Beatriz A. Roel, following completion of the final report. Responses are given in bold. References (e.g. to Figures and Tables) relate to the revised final report. The original Appendix to the review report is not included for the sake of brevity.

Review of the Stock Assessment for the Pacific Herring
Fishery in San Francisco Bay

October 10th and 11th, 2016

Peer Review Panel Members:

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Jake Schweigert and Nathan Taylor
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Pacific Biological Station
Nanaimo, B.C.

Background

On October 10th and 11th, the California Department of Fish and Wildlife organized a peer review of the recently completed stock assessment of San Francisco Bay Pacific herring. A peer review panel consisting of Jake Schweigert and Nathan Taylor of Fisheries and Oceans Canada in Nanaimo, B.C., and Hal Geiger of the St. Hubert Research Group in Juneau, Alaska traveled to Santa Rosa California to meet with modeler Jose De Oliverira from Cefas in the United Kingdom. Also participating were Kirsten Ramey, Ryan Bartling, Tom Barnes, Tom Greiner, and Andrew Weltz of the California Department of Fish and Wildlife, and Sarah Valencia, a consultant hired to develop the management plan for the fishery. The review panel, chaired by Hal Geiger, was given the following objectives: (1) review and discuss the stock assessment and operating models for San Francisco Bay Pacific herring, (2) provide recommendations to the stock assessment modeler for any changes to the assessment, (3) determine whether the final product is appropriate and sufficient for use in management of the Pacific herring fishery in San Francisco Bay via incorporation into the Fishery Management Plan, and (4) provide a written panel report to the Department of Fish and Wildlife.

Prior to the meeting in Santa Rosa, the review panel received a written report (San Francisco Bay Herring: Stock Assessment and evaluation of Harvest Control Rules, by Roel et al., March 2016 version), which formed the basis for most of the review. The panel evaluated the technical merits of the approach, but in the broader context of the management strategy evaluation approach (Punt et al. 2014) described in the Roel et al. report, the panel considered whether any new approach would result in improved fishery outcomes. The panel endorses, in principle, the management strategy evaluation approach for analyzing the effect of alternative management strategy choices. As an analytical instrument, the management strategy evaluation provides a process for evaluating and presenting trade-offs between alternative management strategies (i.e. the choices of data, assessment model, and harvest control rule).
The Punt et al. 2014 reference is not correct. The correct reference, Punt et al. 2016, can be found in the revised final report {Punt, A. E., Butterworth, D. S., de Moor, C. L., De Oliveira, J. A. A. and M. Haddon. 2016. Management strategy evaluation: best practices. Fish and Fisheries, 17(2): 303-334.}.

Comments Related to the Data Used for the Analysis

At the review meeting, the panel was surprised that the modeling appeared to have been conducted with an incomplete and undocumented data set. The panel recommends that prior to further modeling

of the San Francisco Bay Herring population, all data required for model development should be fully reviewed, and that the final data set include all necessary measurements and metrics. If there are any instances where specific years or components of a data series are excluded, then this should be fully explained in a revised report. A process should also be set up to ensure that only a single quality-assured, complete data set is adopted for modeling at a given time. This data set should be maintained for subsequent analyses, and updates or revisions should be tracked by a version-control or report number.
{CDFW to comment}

The decision to restrict the analysis of the San Francisco Bay herring population to the years 1992 to 2013 requires further comment and justification in view of the existence of additional earlier data. The data series that was analyzed reflects a period of reduced harvest levels. The reduced harvest provides limited contrast in the data, which constrains the ability to estimate some model parameters. Moreover, by not using a longer time series of data the model relies on assumptions of the depletion level at the beginning of the modeling period.
Fair comment, although it should be noted that exploitation in the early- to mid-1990s (a period included in the assessment) was substantially higher than recent levels, with 1996 representing the highest landings since at least the early 1970s, therefore we disagree with the comment that the data set used for this development lacks contrast . {CDFW to comment further}

A description of the process used to acquire age-composition data and its application to the derivation of catch at age for the commercial and research surveys is needed in a revised report. A reviewer attempting to understand the unique problems and issues with the input data, such as the sample sizes, measurement error, non-sampling error, or similar issues, can only find statements as brief as this one from page 3: “Input data for the assessment were provided by Tomas Greiner, California Department of fish (sic) and Wildlife,” or “A recruitment index was derived from the Young of the Year surveys.”
{CDFW to comment}

The panel noted the mention of a herring eggs on kelp (HEOK) fishery in the overview on the San Francisco Bay Pacific herring spawning stock and commercial fishery management. However, no information on the landings from the fishery or information on its relative significance was provided in the Roel et al. report. This should be addressed in a revised report. It was not possible for the panel to assess the impact of this herring removal on the stock assessment.
A decision was taken early on to ignore the herring eggs on kelp data {CDFW to comment further}

Comments Related to the Age-Structured Model

The panel agreed that the description of the assessment model in the Roel et al. report was inadequate to allow for complete and thorough review. Additionally, as an aid to review, the panel recommends that a revised report include appendices detailing all parameter estimates for each model run and that additional model runs be included to demonstrate the robustness of the results to varying assumptions and model building decisions.
Appendix 2 now provides a detailed description of the assessment model, with all parameters and variables defined, and with a narrative to “walk” the reader through the model (including more information in the main text). Key results for each of the model runs are now included in the report where these models are discussed. All sensitivity runs, including the additional runs requested during the review process, are included.

The panel found the decision to adopt the hockey-stick stock-recruit function equivocal and not well supported by data. Moreover, the implications of this choice were not clearly communicated to the

reader. The available data are insufficient to demonstrate the relationship between stock size and subsequent recruitment, especially for small stock sizes. The choice of the hockey-stick model results in predictions of unrealistic resilience in the population dynamics, especially at high levels of fishing mortality.
The text on stock-recruit modelling has been expanded to clarify that the hockey-stick model is not actually estimated in the assessment, but instead a simpler form is used. For stock-recruit modelling beyond the assessment (e.g. for stochastic projections), a hockey-stick is used; however, the breakpoint of the hockey-stick is not estimated, but instead placed at the lowest SSB estimated (hence it is termed the "fixed hockey-stick"). The reasons for this (following a well-established procedure used for ICES stocks) is explained in the report, and is related to the fact that there is no evidence, from the estimated stock-recruit pairs, of impaired recruitment at lower stock sizes; under these circumstances, it is not unreasonable to place the breakpoint at the lowest estimated SSB (an approach that is followed in ICES). Robustness to this assumption can of course be tested within an MSE.

The formulations chosen for gear selectivity were confusing and do not adequately reflect what is known about herring biology. The selectivity ogives for the commercial fishery indicated a broad range for round-haul nets and a domed pattern for gillnets (Figure 4 in the Roel et al. report), the latter peaking at about 185 mm corresponding to age-4 herring, a pattern that is consistent with the selectivity of the research trawls shown in Figure 11. However, the selectivity function in the model adopts full selection by the fishery (gillnets since 1998–1999) at age 5 and 6+. The panel agreed that further explanation of these decisions is required.
The assessment model has a non-parametric selectivity formulation (a selectivity parameter is estimated separately for each age). The only constraints imposed on the baseline model (model 6) regarding commercial selectivity are that the selectivity parameter for age 5 is equal to that for age 6, and that the maximum selection for any age is 1 – there are no other constraints imposed. The assessment model relies on the proportions-at-age data to estimate these selectivity parameters; admittedly, there are confounding effects between selectivity and natural mortality (e.g. with the plus-group natural mortality factor). The reason for assuming age 5 equals age 6 for commercial selectivity is not a strong one (it avoids the problems introduced by a cryptic biomass), and could be further explored within an MSE to check robustness of HCRs to competing hypotheses regarding selectivity. These issues are discussed in the report.

The final operating model {The term operating model is used here to mean an overall model to simulate various management outcomes based on models of the stock dynamics, the management, and the data acquisition.} developed for the evaluation of harvest control rules implements a sequential approach to the inclusion of flat topped commercial selectivity, a 2007 natural mortality event associated with the oil spill, a fixed natural mortality and mortality multiplier to age 6 and older herring (Table 4 in the Roel et al. report). However, the explanation for the choice of this version of the model is unconvincing and the mortality multiplier for age 6+ seems ad hoc and arbitrary. It would be helpful to repeat the runs described in Table 4 of the Roel et al. report for all cases with natural mortality fixed at 0.53 as in the final run. The analysts might also consider testing a linear function for mortality from age 3 when fish are fully mature to age 6+. Such an approach could be more readily justified on a biological basis.
There is now a Table 4a (as for the original Table 4) and 4b (where all runs are for M=0.53). Regarding the linear function, for mortality from age 3, we feel sensitivity runs using the Tanasichuk formulation already indicate what would happen: namely unrealistically low estimates of M for the younger ages in order to reach the M needed for the plus-group age 6, when the plus-group age 6 mortality factor is omitted (compare model 11 with model 6).

Decisions about model selection in this report rely heavily on the total likelihood, the largest component of which relates to the fit of the age-composition data. Table A1.3 in the Roel et al. report presents the catch at age for the commercial fishery and Table A1.5 presents the catch at age for the research survey. The research catch-at-age data presented in this version of the report is an order of magnitude larger than the commercial catch at age. This seems implausible. These data also do not reflect the exceptional 2002 or 2003 year classes that produced the large 2005 spawning stock biomass. As we discuss above, the panel again recommends that these data be carefully reviewed and fully documented before conducting further modeling.
The explanation for the magnitude of the research catch-at-age data is given in the caption to the Table – essentially the numbers in the table are raised to the spawning wave estimate so they do not reflect the actual numbers caught in the samples; this information is used as relative proportions-at-age within a year, so the scale is of no consequence. Furthermore, the 2005 SSB index estimate is largely ignored in the model fits, and it is difficult to believe that there could have been such a large pulse in SSB with values for the years on either side being much lower.

The panel also noted that Figure 7 of the Roel et al. report shows an inability of the model to adequately explain the spawning stock biomass index from 2009 to 2013. This result requires further analysis and comment in a revised report. Similarly, no explanation is provided for the positive trend in recruitment residuals (Figure 9 of the Roel et al. report). Some of these residual patterns are symptomatic of poor goodness of fit to the data and the reasons underlying this pattern need to explored and preferably rectified.
We acknowledge there are issues related to the fit to the SSB index and the recruitment residuals; the assessment has high uncertainty (Figure 11). However, we also point to the fits that include a further two years' data, where both issues highlighted by the review seem less relevant (Figures 16 and 18).

Provided that a defensible operating model can be developed, the panel identified several deficiencies in the way the model described in the Roel et al. report simulated herring population dynamics. In particular, the analysis must include more challenging scenarios with which to test the alternative management procedures. In the Roel et al. report, the scenarios involved routine sampling from well-behaved probability distributions that were expected to reproduce historical conditions over a short time scale. Dynamic species like herring have both variable recruitment and variable natural mortality (as environmental conditions change). More challenging scenarios should include periodic el Nino, infrequent catastrophic events, climate change, induced changes in recruitment, or changes in natural mortality, for example. In addition, the analysis would benefit greatly by imbedding the assessment model into future simulations in order to capture assessment model estimation errors that can be very large (Punt et al. 2014). Failing to consider such factors results in an under-estimation of the uncertainty in the range of future outcomes for the stock and the fishery under a given management strategy. That would mean quantities like the probability of breaching a limit reference point could be much higher in reality than what would have been demonstrated in the simulations.
We do not pretend that we have produced a full-blown MSE analysis – we were not contracted to do so, and this is made clear in the report. However, we hope that the analyses presented provide a first step in that direction. An MSE framework is the ideal place for exploring the range of situations mentioned (catastrophic events, climate change, el Niño, etc.), and the sensitivity analysis could provide a basis for alternative operating models in such a framework. [Note, as mentioned before, the Punt et al. 2014 reference is not correct.]

The panel agreed that a broader range of performance statistics is needed to increase the relevance of the work for decision making. Some of these statistics could be quantities such as the probability of being at a target biomass for the stock, the probability of fisheries closures, and the average annual variability in the catch. Moreover, the presentation would benefit from having the performance

statistics partitioned into more time frames. The time horizon for achieving particular objectives or avoiding limits may be particularly important. For example, the application of any particular management strategy may have consequences that are undesirable in the short term (5–10 years) even if in the longer term (over 20 years) performance is good. Performance statistics used in other management strategy evaluations might be useful for application in future analyses (see Taylor et al. 2014, Schweigert et al. 2007, for examples).
We agree with these suggestions, and hope that further MSE development will consider them.

Suggested Revisions to a Final Report

The version of the report the panel received appeared incomplete, contained insufficient material and detail for a full and complete review, and the document contained obvious errors that left the panel wondering about errors that were not as obvious. The panel suggests that the main document be rewritten in the standard Introduction-Methods-Results-Discussion format of a scientific report. Each section should be written in sufficient detail to allow a reader not already fully familiar with the subject to understand and be able to critique the analysis.
We hope that the re-structured and expanded report meets these concerns.

The Introduction should introduce the reader to the history of the fishery, the history of the management process, and explain how the results of the current analysis and modeling would provide a basis for altering existing management approaches. Importantly, the Introduction should specifically lay out the goals and intent for management and for the study. This context is essential for understanding the decisions about the parameterization of the assessment model and also for understanding the relevance of the management strategy evaluation analysis.
{CDFW to comment}

The Methods should contain a complete review of the all data sources (see the section on Comments Related to the Data Used for the Analysis, above). As previously mentioned, this review should allow the reader to understand how far back in time the data series goes, understand the sampling design for the survey index, understand the protocols for the ageing data, understand the sampling design for the commercial age-composition data, understand what data exist from prior to 1992 and why these data were not used, and so forth. Additionally, the Methods should fully introduce the models. The revised report should contain descriptions relating to the choice of the stock-recruitment function, gear selectivity, natural mortality, and the maturity ogive. The Methods should cite authorities, describe where the models came from, and include a narrative that introduces notation and describes the parameters to readers not familiar with the models. This section should tell the readers how the state dynamics are updated at each time step, how the subsequent model fitting procedure occurs (including choice of likelihood function formulation), and so on. In summary, this section should contain sufficient detail for a reader to be able to reproduce the analysis after reference to materials in any appendices.
{CDFW to comment on the data part} We hope the re-structured and expanded report addresses these concerns.

In the Roel et al. report, the material relating to the methods appears to have been written for someone already fully familiar with the model. In other words, this material appears to have been written for someone that only needs brief reminders of model notation rather than a presentation introducing the material for the first time. A section of the document found under the heading of "Assessment Model" contains a few facts about the model, but no explanation of model development or any of the theory underpinning the model. The reader is incorrectly referred to Appendix 1 of the Roel et al. report for a "generic description of the model." Appendix 1 contains tables of input data; Appendix 2 does contain over five pages of lists of equations—not a "generic description of the

model." The equations in Appendix 2 were introduced without explanation, and equations in Appendix 2 appear before the notation is introduced to the reader.
We hope the re-structured and expanded report addresses these concerns.

When the reader does discover Appendix 3 in the report, the reader finds only brief reminders of the meaning of the notation. For example, the notation F is commonly used in age-structured models in North America to mean the instantaneous fishing mortality. In Appendix 3, F(y,a) is defined as fishing mortality at age a in year y. This brief comment fails to clearly tell the reader that F is being used to denote a kind of harvest rate. The reader is left to see by inspection of equation A2.1 that if F indicates instantaneous mortality then this equation does not make sense. Similarly, C(f,y) is described as "Catch of fleet f in year y." To fully understand the meaning of this notation in equation A2.3 the reader will need to correctly guess that C is in units of weight or mass or else carefully inspect the units of the other quantities in equations that contain C so as to infer the appropriate units. In North America C is often used to denote catch in units of individual fish. Some of the equations may contain errors, but the panel was unable to decode the notation, infer the meaning of the equations, and check the equations in Appendix 2 carefully in the time available. Some narrative walking the reader through the equations should be considered essential in a revised report.
There is no longer a notation Appendix. All definitions are included in the narrative provided in revised Appendix 2.

The Results section should lead the reader through the results in a logical manner so that the reader will be able to understand and digest the material in the figures and tables. In most cases, the tables and figures in the version of the report that the panel was given were insufficient for their intended purpose. Most graphics were too small and many had unlabeled axes. Table captions did not describe the table contents adequately. Graphics and tables were usually introduced without any kind of interpretation or context (e.g., "Model fits to the SSB and recruitment indices are shown in Figure 7."). Figure 6 in the Roel et al. report is described in the figure caption as a "Likelihood profile," yet the preferred estimate is shown at some kind of minimum—not the maximum. In this case there is an axis label, but that axis is described with the nonspecific term "Function value." The reader is left to decide whether the figure caption is wrong and "Function value" means the negative log likelihood rather than likelihood, decide whether this is simply the entirely incorrect figure that was included by mistake, or whether something else happened. All of the figures should be reviewed and brought up to the standards that are usually required for a scientific publication. In contrast, note that Figure 12 in the report provides a good example of a helpful graphic. Here the axis labels and the figure caption complement each other. The figure works to allow the reader to understand a complex point about the model fitting that is important to understand the limits of the model's ability to predict.
Improvements have been made throughout to Tables and Figures, as suggested.

The panel was surprised to find that the report they reviewed contained essentially no discussion of the important implications for the use of the estimated model in fishery management. This important section of the report should be a place where the model results are placed in context for the reader, a place for synthesis and integration of new information with historical information, and a place where uncertainty and limitations are carefully explained to the reader. A carefully constructed Discussion in the report is the place to try and communicate these limitations to the fishery management, the fishing industry, and other concerned organizations and individuals.
We hope expansion of the Discussion and improvements to the report addresses this concern.
{CDFW to provide some context for fisheries management?}

Much more importantly, there is no discussion of the important conflict between predicted yield based on the proposed model and the actual fishery performance in the past. The panel noted that the proposed model predicts that yield will increase as the harvest rate increases from 0.0 all the way to

1.0 (Table 6 and Figure 15 in the Roel et al. report). This result is both surprising and counter-intuitive. Additionally, this result also serves to demonstrate how new models can create a potential liability for management's credibility if the management has not carefully validated the model.
Figures 25a and b, and the text around them deals with this concern. There is also text on why it is that we are seeing this "resilient" behaviour, related to the evaluating the maturity ogive relative to the commercial selectivity pattern (Figure 24).

In contrast to the prediction that very high harvest rates are sustainable, the panel that conducted the 2003 review of San Francisco Bay herring (see Appendix A attached to this review) concluded that harvest rates at that time had been too high and were not sustainable. The 2003 panel specifically stated the following: "The current harvest strategy for this stock should be re-evaluated and explicitly documented. The current harvest rate policy of 20% appears to be too aggressive under current levels of stock production. A harvest rate in the range of 10–15% appears to be sustainable with the lower level providing a desirable target for stock rebuilding." The Roel at al. model's prediction that a 100% harvest of the available population in the future would be sustainable and the observation that a 20% harvest in the past had been considered excessive obviously needs to be brought out in a Discussion and reconciled.
We have a paragraph in the Discussion that specifically deals with this.

There were 10 paragraphs in the Conclusions. Some of these conclusions appeared to be correct but not supported by evidence found in the report (e.g., see the first paragraph in the Conclusions). The panel also questioned whether other statements were correct or not. Either way, the team agreed this section should be revised, expanded, or combined with a new Discussion section.
The Discussion section has been expanded and revised, and any conclusions should be substantiated by the results shown earlier in the report.

Final Comments and Recommendations

Before a management agency adopts a complex model into its management strategy, the agency should have a clear understanding of how the model is going to be used. The agency should also have given adequate thought to the consequences of assumptions and choices in model development that might simply be wrong. These considerations should affect any future review.

An age-structured model could be used either to study the effects of various management actions or strategies (i.e., the management strategy evaluation), or the model could be used for short-term decision making, such as setting a total allowable catch. These two uses are not the same. For example, a model of herring dynamics might be quite useful and safe as a way to combine fishery-derived information with fishery-independent information so as to smooth out random fluctuations in a spawn deposition survey to set harvest rates when fishing mortality is low. Yet, this same model may completely fail to predict the stock dynamics at very high fishing mortality—especially when the model is used to predict what will happen far outside the range of the data that was used to construct the model.

Roel et al. cite "Punt et al. (in press)" (this should now be cited at Punt et al. (2014), which is how we have cited it) as a key reference on the management strategy evaluation (MSE) approach. Punt et al. stress, "The ability of MSE to facilitate fisheries management achieving its aims depends on how well uncertainty is represented, and how effectively the results of simulations are summarized and presented to the decision-makers." In other words, it is not good enough to simply have an operating model, assessment model, and a set of closed loop simulations. A complete management strategy evaluation involves a careful study of uncertainty—including a careful analysis of "what if we are wrong." At a minimum the assessment must address this question: what if the population dynamics in

nature are different from those assumed in the assessment? There are many layers of uncertainty involved in modeling herring dynamics, including uncertainty as a result of a random and possibly changing environment, uncertainty due to estimation and sampling error, uncertainty that could be the result of incorrect assumption or modeling decisions. Prior to further review, the analysis needs a much more sophisticated study of uncertainty. The panel agrees that the cited Punt et al. article could be used as a guide.
We have not attempted a full MSE – we were not contracted to do this. However, as indicated before, we hope the work done can form the initial steps for further development. Again, note the incorrect reference to Punt et al. 2014 here (as highlighted before).

The panel recommends that the California Department of Fish and Wildlife at least consider some simpler, more cost effective management tools. Age-structured assessment models can be demanding in terms of both data and in the capacity to use these tools. The capacities to run, update, and explain such models within the agency may be limited, expensive, and may divert resources way from more important needs. In some cases adopting the age-structured modeling approach for annual decision-making may even erode fishery outcomes if the effects of the models are not well understood or if the models poorly predict the dynamics of the population. Many alternative assessment models or management based on smoothed survey estimates could be less costly and potentially more effective. For example, Kalman filtering (Walters 2004) has been evaluated in other herring fisheries (Cleary et al. 2010). Even with these simpler tools in place to set catch limits, management strategy evaluation simulations could be used to illustrate how these alternative models perform in terms of catch, variability and conservation metrics with similar or different harvest control rules. It may be possible to show with a more complete accounting of uncertainty that a harvest control rule based on the annual survey could have a similar, or even better, performance without the cost and complexity of adopting an annual age-structured modeling calculation and evaluation.
Note, however, that the evaluation of these potentially simpler approaches still require the more complex operating models, a point that is often made in the MSE "literature" (see e.g. Geromont and Butterworth 2015 {Geromont, H. F., and D.S. Butterworth. 2015 Complex assessments or simple management procedures for efficient fisheries management: a comparative study. ICES Journal of Marine Science, 72: 262–274.}).

In anticipation of future modeling in support of management strategy evaluation, the panel recommends that California Department of Fisheries and Wildlife engage with stakeholders to develop objectives and performance indicators for the management of the fishery. The single factor of breaching the precautionary limit biomass, or the putative limit reference point, with greater than 5% probability, examined in the Roel et al. report, is unlikely to universally satisfy the larger community. For example, the panel heard during the review that some individuals and organizations might be concerned about addressing the broader ecosystem consequences of the fishery on a forage fish like herring. In this case, the metrics identified in some of the forage fish literature (Essington et al. 2015, Smith et al. 2011) may be very important.

Additionally, management strategy evaluations (Hall et al. 1988 for a herring-specific example) have documented that the objectives typically trade off against each other. For example, high average catches occur at the expense of high variability in catch. By failing to consider a broader set of objectives it is not possible to understand the broader set of consequences of applying a given management strategy on the industry, the stock, or the ecosystem.

Given the concerns about aspects of the development of the operating model based on the relatively short time series and outstanding questions about the data and the ability of such a model to reasonably predict the future productivity and resilience of the San Francisco Bay herring population given climate warming and unpredictable catastrophic events, the panel cannot endorse the model described in the Roel et al. report for the development of harvest control rules and reference points at this time.

It is possible to deal with future productivity and resilience scenarios, given e.g. climate change and unpredictable catastrophic events, within an MSE framework without needing to deal with it directly in the assessment model (often difficult or impossible to do), so we are not sure that this is an argument to reject the models presented(see e.g. Punt et al. 2014, which is a different paper to Punt et al. 2016 {Punt, A. E., A'mar, T., Bond, N. A., Butterworth, D. S., de Moor, C. L., De Oliveira, J. A. A., Haltuch, M. A., Hollowed, A. B. and C. Szuwalski. 2014. Fisheries management under climate and environmental uncertainty: control rules and performance simulation. ICES Journal of Marine Science, 71: 2208–2220.}).

As a concluding recommendation, the panel again recommends that the California Department of Fish and Wildlife adopt a stronger policy of documentation. Details of each year's surveys and monitoring should be recorded and archived at least in timely internal reports.

Finally, the panel strongly commends the professionalism of the California Department of Fisheries and Wildlife staff. Their dedication to the annual collection of herring assessment data, given their limited resources, is indicative of their vision and commitment. This herring assessment data provides the basis for any rigorous statistical analyses, the modeling effort reviewed here, or any kind of rational management.

Acknowledgement

The panel thanks Jose De Oliveira for his patient help explaining the model, for conducting additional simulations for the panel, and for all his help in the review. We also thank Andrew Weltz and Tom Greiner for their help in understanding the history of spawning survey and the management. We thank Tom Barnes, Ryan Bartling, and Kirsten Ramey for organizing the review and for their warm hospitality while we were in Santa Rosa.

Literature Cited in the Review

Cleary, J. S., S. P. Cox, and J. F. Schweigert. 2010. Performance evaluation of harvest control rules for Pacific herring management in British Columbia, Canada. ICES Journal of Marine Science 67:2005-2011.

Essington, T. E., P. E. Moriarty, H. E. Froehlich, E. E. Hodgson, L. E. Koehn, K. L. Oken, M. C. Siple, and C. C. Stawitz. 2015. Fishing amplifies forage fish population collapses. Proceedings of the National Academy of Sciences 112:6648-6652.

Hall, D. L., R. Hilborn, M. Stocker, and C. J. Walters. 1988. Alternative harvest strategies for Pacific herring (Clupea harengus pallasi). Canadian Journal of Fisheries and Aquatic Sciences 45:888-897.

Punt, A. E., Butterworth, D. S., Moor, C. L., De Oliveira, J. A., and Haddon, M. 2014. Management strategy evaluation: best practices. Fish and Fisheries: 3-32.

Roel, B.A., N.D. Walker, and J.A.A. De Oliveira. 2016. San Francisco Bay Herring, Stock Assessment and evaluation of harvest control rules. Draft Manuscript prepared by Cefas for the peer review. 43 p.

Schweigert, J.F., Fu, C., Wood, C.C., and T.W. Therriault. 2007. A risk assessment framework for Pacific herring stocks in British Columbia. Canadian Science Advisory Secretariat Research Document 2007/047: 78p.

Smith, A. D. M., C. J. Brown, C. M. Bulman, E. A. Fulton, P. Johnson, I. C. Kaplan, H. Lozano-Montes, S. Mackinson, M. Marzloff, L. J. Shannon, Y.-J. Shin, and J. Tam. 2011. Impacts of Fishing Low–Trophic Level Species on Marine Ecosystems. Science 333:11471150.

Taylor, N.G., Hicks, A.E., Grandin, C. Taylor, I.J. and Cox, S.P. 2014. Status of Pacific Hake (Whiting) stock in U.S. and Canadian waters in 2013 with a management strategy evaluation. International Joint Technical Committee for Pacific Hake. 196p.

Walters, C. J. 2004. Simple representation of the dynamics of biomass error propagation for stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 61:1061-1065.

San Francisco Bay Herring

Stock Assessment and Initial Evaluation of Harvest Control Rules

Report prepared by B. A. Roel, N. D. Walker and J. A. A. De Oliveira
Revised by J. A. A. De Oliveira and B. A. Roel

March 2016 (revised January 2017)

Cefas

EXECUTIVE SUMMARY

The modelling work presented consists of an assessment of the San Francisco Bay herring stock, using a statistical catch-at-age model fitted to data supplied by the California Department of Fish and Wildlife. A number of model explorations and sensitivity tests were conducted, which included investigating aspects related to the stock-recruit relationship, fishery selection and natural mortality. The development of the assessment model, which formed the backbone of the project, was followed by the development of an operating model to test simple harvest control rules. The operating model was conditioned on the assessment. Precautionary and MSY reference points for management were investigated. A harvest control rule, based on a constant exploitation rate with a precautionary reduction when the stock was low, was evaluated by simulation. The model-estimated commercial gear selectivity resulted in a substantial proportion of mature individuals always surviving the fishery, even in the case of high fishing pressure. This resulted in the associated risk (probability of spawning stock biomass falling below the limit biomass reference point, Blim) not exceeding 15.2%, even under maximum fishing pressure. However, the uncertainty in model parameters was large, which resulted in 4.1% risk of falling below Blim in the absence of exploitation. Harvest rates between 10 and 20% had associated risks between 5.6 and 7.0%. Summary statistics for a range of exploitation rates are presented for managers' consideration.

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Introduction

In July 2011 Cefas was contracted by Mr Nick Sohrakoff, President of the San Francisco Bay Herring Association, to develop an assessment model for California Bay herring and to provide tools to better manage the stock. A peer review process was anticipated to take place once Cefas had finalised the agreed (contracted) work and submitted their Report to the California Department of Fish and Wildlife (CDFW). Subsequent to the physical peer review process that took place in Santa Rosa, California, on 10 and 11 October 2016 (with one of the Cefas team present) and the production of the formal review report in November 2016, Cefas and the client agreed that, for the purposes of addressing certain of the requests made in the review, detailed descriptions of the data used in the study, the history of the fishery and the management process would be provided by CDFW. Cefas would then focus on development of the assessment model and stochastic projections that could be used to evaluate basic harvest control rules.

The goals of the study were originally agreed between Cefas and the scientific staff from the California Department of Fish and Wildlife (CDFW) during the early stages of negotiation of the Contract between the two organisations. Currently, the stock is managed on the basis of a total allowable catch (TAC) set at the start of the fishing season. The TAC is computed as a fixed percentage of the spawning stock biomass (SSB) as estimated from an egg survey conducted during the previous year’s spawning season. The survey results are, however, considered to be rather noisy, so the TAC tends to be highly variable between years. Further, uncertainty in the survey results is not taken into account in the process of determining the TAC. The present study proposes a management approach that takes into account all existing and available sources of data, both commercial and research. This proposal would be achieved by annually assessing the stock using an analytical model developed by Cefas that would integrate all appropriate data sources provided by CDFW. The outcome from the assessment would constitute the input into a harvest control rule derived from a management strategy evaluation (MSE) process.

In the study, Cefas first examined the data made available by CDFW and provided guidance to process the data required by the assessment model. In short, Cefas’ scientists worked with CDFW on criteria and procedures to compute catch-at-age data by allocating age composition samples to sampled and unsampled landings for both commercial and research catches; research data and Young of the Year (YoY) surveys were examined and a recruitment index based on the YoY surveys was constructed. The development and implementation of an age-structured production model formed the core of this study; a range of analyses to test the sensitivity of the results to model key assumptions was subsequently performed. Finally, stochastic projections conditioned on the assessment model were conducted to test the performance of alternative, simple harvest control rules. This (revised) Report reflects all the scientific work carried out by Cefas during the original contract period (up to presenting the first report) and subsequently, following production of the formal review.

Material and Methods

Data

The data used in the assessment consists of landings, maturity data and mortality data, commercial numbers at age landed and research numbers at age caught (catch-at-age data), mean weights at age, spawning biomass estimates from the egg deposition surveys and a recruitment index derived from Young of the Year (YoY) surveys. A full description of the data used in the model is being provided by CDFW. The model input data set is shown in Appendix 1.

Recruitment index

A recruitment index was derived from the YoY surveys (Baxter *et al*. 1999, Watters and Oda 1997). Figure 1 shows length frequencies for the YoY surveys, summed over the period 1980-2012, for the midwater trawl gear. A clear feature of this plot is that age 0 fish are most prevalent in the Bay during the months of April to July, and less prevalent from August on, when they are likely to have started leaving the bay.

Figure 2 shows within-cohort consistency between the YoY survey at age 0, and the research catch-at-age at ages 1–6. When using a recruitment index made up of the average of the YoY surveys for the months April–September, there is almost no consistency between the recruitment index and the research catches (left panel, Figure 2); however, when the index averages the months April–July of the YoY surveys, then consistency improves somewhat, and significantly positive correlations are found between age 0 (the recruitment index) and ages 2 and 3, with positive (but not significant) correlations between age 0 and ages 4 and 5. These features support the use of a recruitment index calculated as the average of the YoY surveys for the months April–July, which is what is used for the results presented in this document. This is consistent with the use of these data by Watters and Oda (1997). Note that there is no correlation between age 0 and age 1; this is because juveniles move out of the bay and only come back to spawn once they mature at age 2.

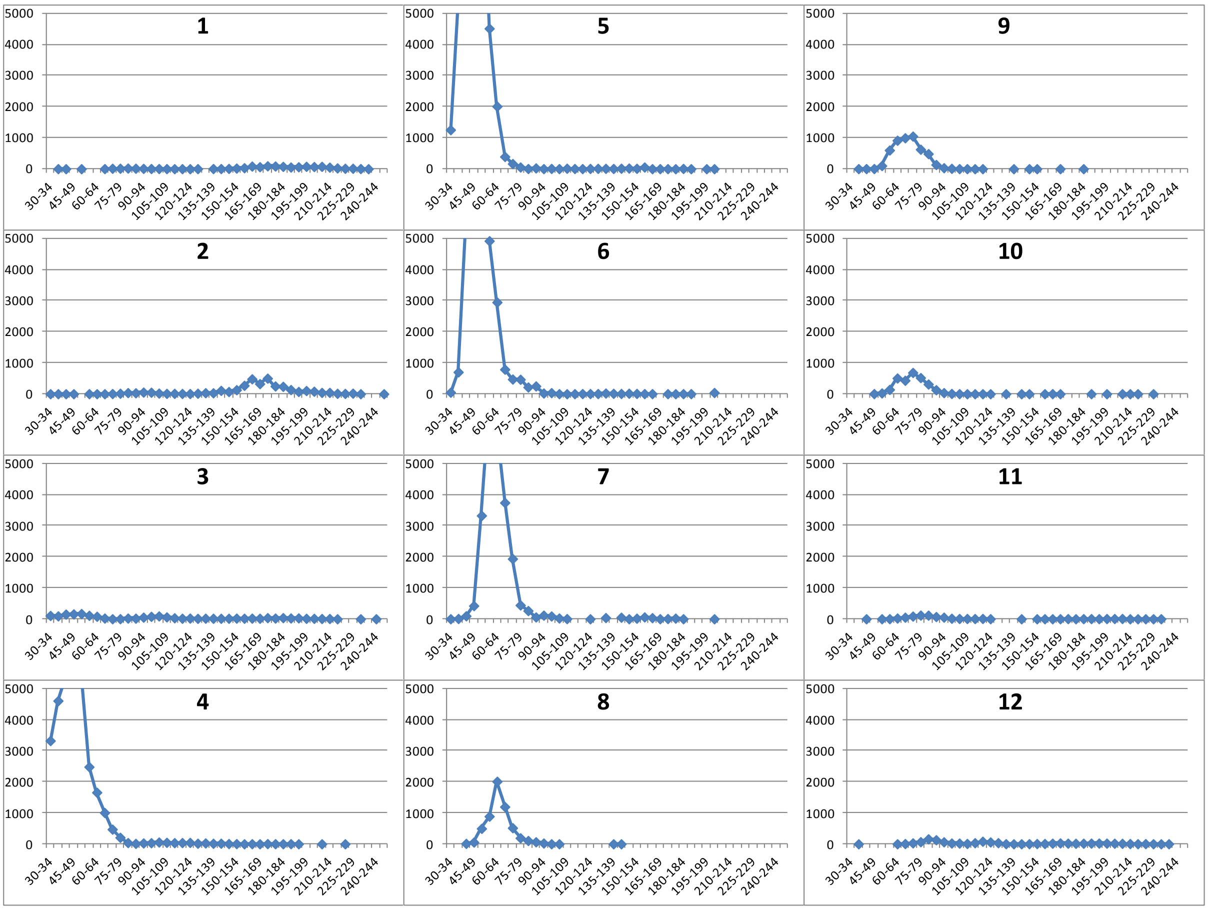

Figure 1. Length frequencies by month for the YoY surveys summed over 1980–2012 for the midwater trawl gear.

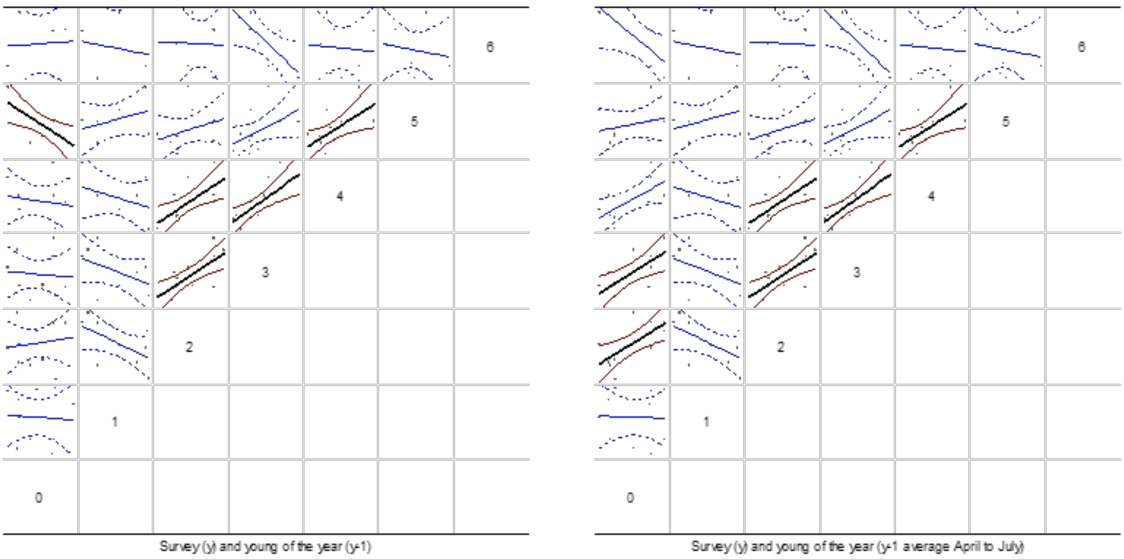

Figure 2. Within-cohort consistency in the research catch-at-age matrix (ages 1-6) and the YoY survey (age 0), shown by plotting the log-catch of a cohort at a particular age against the log-catch of the same cohort at subsequent ages. Regression and 95% confidence intervals included. Left panel gives the YoY survey averaged over April–September, the right panel gives the same index but averaged over months Apri–July. Thick black lines (with confidence intervals in red) represent a significant ($p<0.05$) regression and the curved lines are approximate 95% confidence intervals.

Assessment Model

The model is an age-structured production model (ASPM), introduced by Hilborn (1990) as an extension of age-aggregated production models (e.g. that of Schaefer, 1957). ASPMs essentially replace the estimation of the Schaefer model r and K with parameters of the stock–recruit relationship, and if that function has a stochastic component and catch-at-age data (either from commercial or research survey catches) are used in the fitting process, the ASPM is essentially a statistical catch-at-age model. This is the model that is used for San Francisco Bay herring, and is similar to the approach described by Butterworth and Rademeyer (2008; see Section B of their Supplementary Material).

Appendix 2 provides a detailed mathematical description of the model. The model is fitted using maximum likelihood estimation and relies on a number of data sources. The model fits directly to an SSB index (from an egg deposition survey), a recruitment index (from a Young of the Year survey), catch-at-age data (converted to proportions-at-age) from a commercial fishery, and catch-at-age data (also converted to proportions-at-age) from research catches. Details of the likelihood components for each data source are provided in Appendix 2. In addition to these data sources, a penalized likelihood term is included to model recruitment deviations from an estimated stock–recruit relationship.

Population dynamics follow the usual exponential decay equations, commencing from recruitment, through a stock–recruit relationship (Appendix 2, A2.1-A2.10), and using Pope's approximation (Pope 1972), which assumes pulse fishing in the middle of the fishing season. Instead of modelling instantaneous fishing mortality, harvest rates are used (restricted to be no less than zero and no more than 1; Appendix 2, A2.2-A2.3), calculated using the actual total catch tonnage (assumed without error; Appendix 2, A2.3). An initial unfished age structure is used, but because a fishery already existed in 1992, this is reduced by a proportion (p_{virgin}; Appendix 2, A2.11-A2.12). Fishery and survey selectivity-at-age is modelled through a non-parametric formulation (Appendix 2, A2.15 and subsequent text), and model estimates that correspond to the data observed are obtained for the surveys (Appendix 2, A2-17a-b) and proportions-at-age (Appendix 2, A2.18-A2.19), with the survey indices scaled to the observations by estimating constants of proportionality (Appendix 2, A2.21). The model relies on likelihood formulations for each data source (Appendix 2, A2.26-A2.29) and a penalized likelihood term for recruitment (Appendix 2, A2.30-A2.31). Quasi-Newton minimisation (using AD Model Builder; Fournier et al. 2012) is applied to estimate model parameters by minimising the total negative log-likelihood function (Appendix 2, A2.33).

Stock–recruitment relationship

The assessment assumed a stock and recruitment relationship to initialise recruitment. Three functional forms were investigated: Beverton–Holt, Shepherd, and a simple form based on virgin recruitment. Parameterisation is described in Appendix 2 (A2.5-A2.10). These initial investigations were carried out using natural mortality estimates for North Sea herring; this was later abandoned for the baseline assessment in favour of deriving natural mortality estimates based on the San Francisco Bay herring assessment. Nevertheless, the conclusions of this section regarding which stock–recruitment function to use should be robust to the natural mortality values used (since all stock–recruit functions will use the same natural mortality assumption).

Beverton-Holt:
The Beverton–Holt stock–recruit function is a special case of the Shepherd function (obtained when γ =1; Appendix 2, A2.5). Stock and recruitment parameter estimates obtained are shown in Table 1a. The fit to the data is shown in Figure 3.

Table 1a. Beverton and Holt functional form, parameter estimates (K^{sp} in tonnes). The negative log-likelihood ($-\ln L$) is included. [Note, this is identical to γ=1 in Table 1b.].

Parameter	value	stdev	CV
$\ln K^{sp}$	11.10	0.19	0.02
h	0.79	0.39	0.49
K^{sp}	65898	12607	0.19
α	494920	122520	0.25
β	4545	11657	2.56
$-\ln L$	355.83		

Shepherd:
The shape parameter, γ, of this function could not be estimated; therefore, the approach taken was to fix γ at values from 0.5 to 2.0, at 0.1 intervals; γ values less than 0.9 resulted in unrealistic parameter estimates (β became negative). Steepness was better estimated as γ increased while K^{sp} slightly deteriorated. Results for a set of γ values are shown in Table 1b and in Figure 3:

Table 1b. Shepherd functional form, parameter estimates for a range of γ values between 0.9 and 2 (K^{sp} in tonnes). The negative log-likelihood ($-\ln L$) is included.

Parameter	γ = 0.9			γ = 1			γ = 1.1			γ = 1.5			γ = 2		
	value	stdev	CV	value	stdev	CV	value	stdev	CV	value	stdev	CV	value	stdev	CV
$\ln K^{sp}$	11.09	0.19	0.02	11.10	0.19	0.02	11.10	0.19	0.02	11.11	0.21	0.02	11.14	0.23	0.02
h	0.83	0.43	0.52	0.79	0.39	0.49	0.76	0.36	0.47	0.66	0.27	0.41	0.56	0.21	0.37
K^{sp}	65743	12369	0.19	65898	12607	0.19	66080	12863	0.19	67050	14082	0.21	68676	16030	0.23
α	153600	35282	0.23	494920	122520	0.25	1583500	422770	0.27	159440000	57156000	0.36	49303000000	24638000000	0.50
β	182	3581	19.70	4545	11657	2.56	24907	37962	1.52	5331500	4363700	0.82	2300900000	1733600000	0.75
$-\ln L$	355.72			355.83			355.95			356.46			357.13		

Simple stock–recruit function based on virgin recruitment:
A simple stock–recruit function, based on virgin recruitment alone (Appendix 2, A2.8) was fitted. If an SSB breakpoint is included at an appropriate SSB value (i.e. where the curve starts to decline linearly to zero), such a relationship is called a "hockey-stick" formulation (see e.g. Mesnil and Rochet 2010). Because the use of a relationship that is completely independent of SSB is not sensible when conducting stochastic projections or evaluating harvest control rules (see Appendix 2), the simple stock–recruit function can be formulated as a hockey-stick model, but it is important to note that the SSB breakpoint is not estimated in the assessment results presented (and we therefore refer to it as the "fixed hockey-stick form here on). The fixed hockey stick shown in Figure 3 (bottom right plot) places the SSB breakpoint at the lowest estimated SSB, because there is no evidence in the stock–recruit plot of reduced recruitment at low stock sizes – this is standard practice in ICES for this type of stock–recruit plot (ICES 2016b). Virgin recruitment (R_{virgin}) was estimated at 467 210 (thousands of fish) with a CV of 0.20 (the associated K^{sp} estimate was 66 499 tonnes with a

CV of 0.20). The simple stock–recruit function is formulated as a fixed hockey-stick model in comparisons below.

Comparison between functional forms:
Likelihood values were similar for all options (Table 2). The fits to the data under the different functional forms considered are shown in Figure 3.

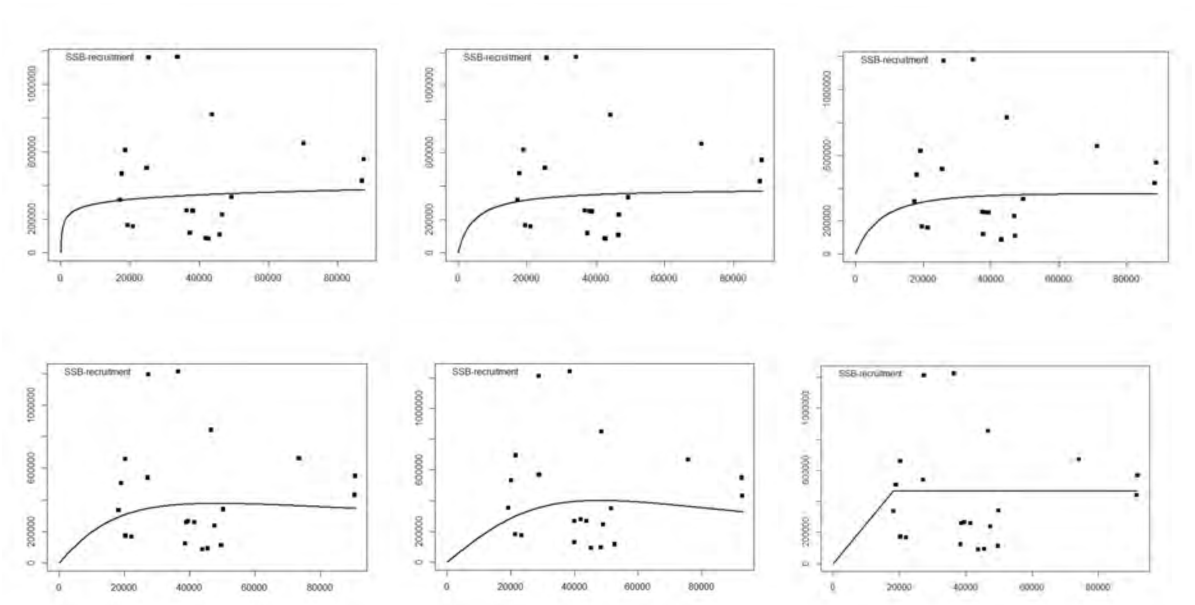

Figure 3. Fits to the stock and recruitment pairs fixing the Shepherd gamma parameter to 0.9, 1 (equivalent to Beverton–Holt), 1.1, 1.5 and 2 (from top left to bottom centre). Bottom right plot illustrates the fixed hockey stick fit (note here that the SSB breakpoint of the hockey stick is not fitted, but placed at the lowest estimated SSB – only the recruitment level, indicated by the horizontal line, is estimated). SSB (horizontal axis) in tonnes, and recruitment (vertical axis) in thousands.

Table 2. Comparison between the three functional forms investigated. "Maximum gradient" is the maximum absolute value of the gradient vector (which has one element per estimable parameter) associated with the negative log-likelihood function ($-\ln L$; Appendix 2, A2.33).

	Beverton-Holt	Shepherd γ= 1.1	Fixed Hockey-stick
Negative log-likelihood	355.83	355.95	355.92
Maximum gradient	4.15E-05	4.39E-05	5.05E-05
Estimable parameters	40	40	39

Goodness-of-fit considerations did not provide a basis for a choice between the functional forms investigated (see Table 2 above; note that other values for the γ Shepherd parameter resulted in similar likelihood, as shown in Table 1b). However, subsequent trials conducted to estimate M indicated that the uncertainty in the steepness parameter present in both Beverton–Holt and Shepherd forms resulted in an unstable minimum when trying to estimate natural mortality (see sensitivity tests below). This feature favoured the use of the simple stock–recruit form, which we term fixed hockey stick for convenience and to reflect the fact that only the level is estimated, with the breakpoint fixed (after the model is fitted, so it has no influence on the model fit) at the lowest SSB in the assessment. The fixed hockey-stick is the form that is adopted in the baseline model.

Selectivity

Fishery selectivity:

There has been a change in selection for the commercial fishery, evident in the length frequencies from commercial catches for round-haul and gillnet (Figure 4). The use of round-haul was phased out gradually and was no longer in use from the 1998/9 season on. The inclusion in the analysis of catch-at-age data from 1992 on has allowed two periods of selection to be estimated in the baseline model, namely 1992–1997 and 1998–2013. Further sensitivity tests are described below.

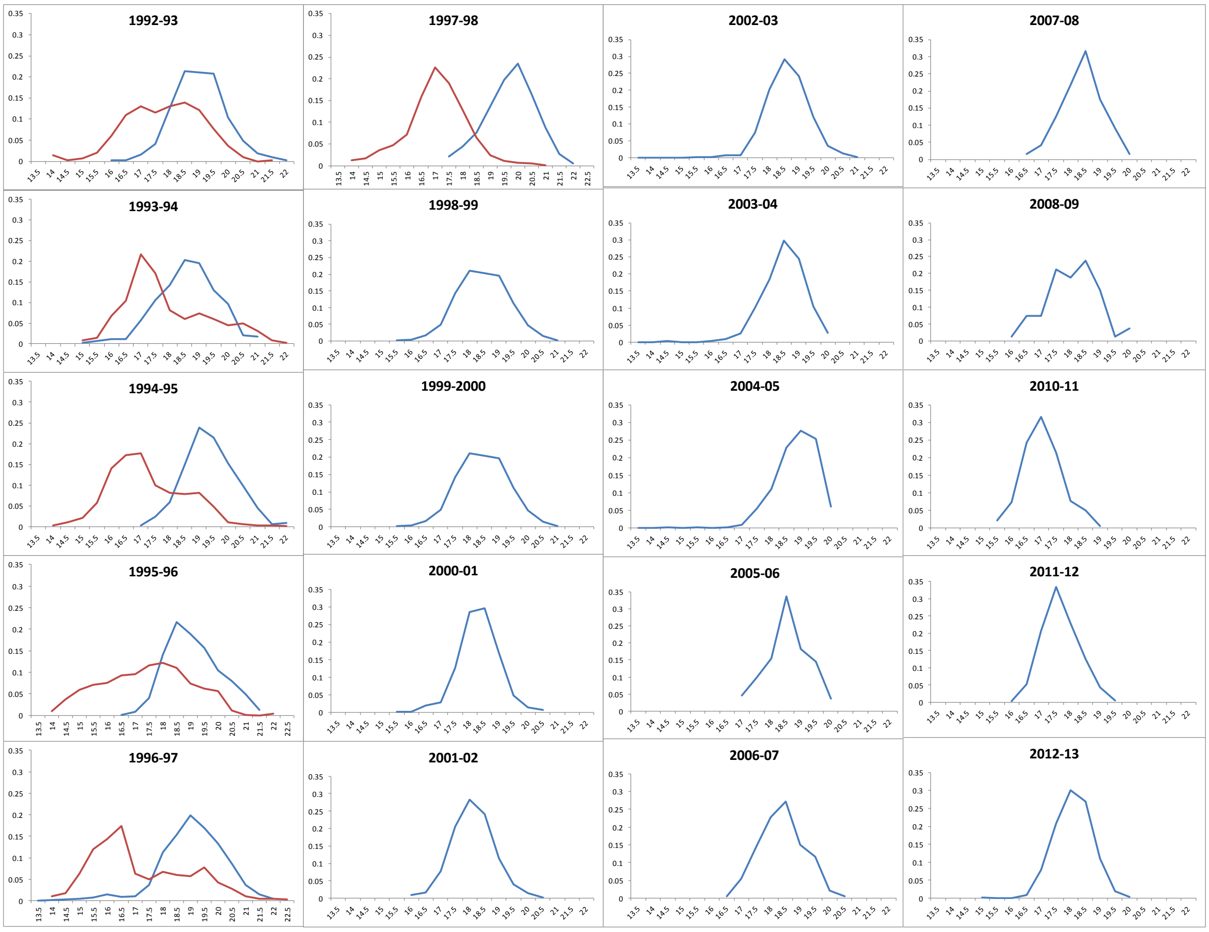

Figure 4. Commercial catch : relative length frequencies (vertical axis) in standardised half cm length bins (horizontal axis) by season, where red corresponds to round-haul and blue to gillnet. [Note that the round-haul gear ceased to operate after the 1997-98 season.]

Survey selectivity:

Samples are usually taken once per week throughout the spawning season. Trawling is the preferred sampling method for research catches, but gillnet samples are used if the trawl vessel is not available or the fish are in shallow water not accessible to the trawl gear; this happens during most seasons. The number of samples taken by each gear type varies from year to year, but trawl samples always dominate numerically. The proportion of fish caught by the two sampling methods is fairly similar from year to year, with no time trend evident in the proportion of trawl vs. gillnet sampling.

Setting up the initial model

Model runs were initially based on values of natural mortality taken from North Sea herring (e.g. the stock–recruit results above; see Table A1.2). This process was later abandoned, and a single value for natural mortality, M, estimated, because North Sea herring values were only being used as a proxy for those for San Francisco Bay herring to initiate the modelling, and therefore were potentially inappropriate. All subsequent results avoid the use of the North Sea herring natural mortality values.

Input values for the recruitment variability σ_R, and the depletion level relative to the virgin stock at the start of the assessment, p_{virgin}, were needed to run the model. The methodology used to derive values for these two parameters was to perform a likelihood profile over these parameters jointly with values selected being σ_R=0.7 and p_{virgin}=0.75, which gave negative log-likelihood values close to the minimum. This was done early in the modelling process, and all subsequent modelling used these two values. The minimum for p_{virgin} (close to 1) was not selected because the fishery was already well-established in 1992, the starting year for the assessment. Nevertheless, the values chosen were within the 95% confidence intervals for these parameters. This is illustrated for the baseline model (model selected after examination of alternative model configurations, see Results section) in Figure 5 and Table 3 which show negative log-likelihood values for a range of σ_R and p_{virgin} value.

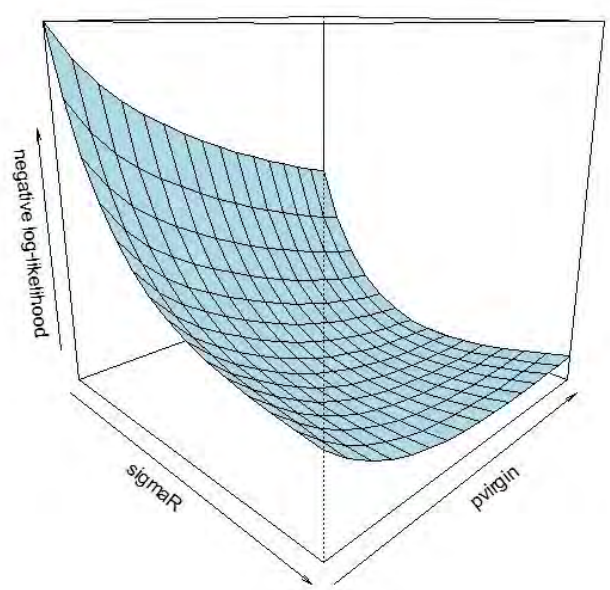

Figure 5. Negative log-likelihood surface for recruitment variability (σ_R, indicated as "sigmaR" in the plot) and proportion of virgin biomass (p_{virgin}). Corresponding values are shown in Table 3.

Table 3. Negative log-likelihood values associated with different combinations of parameters □$_R$ and p_{virgin}, as shown in Figure 5. The shaded region reflects combinations that fall within minimum (the cell with surrounding border) + 1.92, which represents the 95% confidence region for these parameter combinations (likelihood ratio criterion). The parameter combination in bold and darker shade are the values used for all modelling (i.e. □$_R$=0.7 and p_{virgin}=0.75).

	p_{virgin}															
□$_R$	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
0.3	388.57	385.66	383.49	381.84	380.54	379.39	378.35	377.40	376.52	375.71	374.97	374.28	373.63	373.03	372.47	371.95
0.35	382.60	379.78	377.68	376.09	374.85	373.78	372.79	371.88	371.04	370.27	369.55	368.89	368.27	367.70	367.18	366.71
0.4	378.17	375.46	373.46	371.94	370.77	369.74	368.79	367.92	367.11	366.37	365.69	365.06	364.50	363.98	363.53	363.13
0.45	374.85	372.27	370.37	368.94	367.82	366.82	365.90	365.05	364.27	363.57	362.93	362.35	361.85	361.40	361.01	360.68
0.5	372.34	369.89	368.10	366.76	365.68	364.69	363.79	362.96	362.22	361.55	360.97	360.45	360.01	359.63	359.31	359.05
0.55	370.42	368.11	366.43	365.18	364.11	363.13	362.24	361.44	360.74	360.12	359.59	359.14	358.76	358.45	358.19	357.99
0.6	368.94	366.77	365.21	364.02	362.94	361.97	361.11	360.35	359.69	359.13	358.67	358.28	357.96	357.71	357.51	357.36
0.65	367.81	365.78	364.33	363.14	362.07	361.12	360.29	359.58	358.98	358.49	358.08	357.75	357.50	357.30	357.16	357.05
0.7	366.94	365.05	363.68	362.48	361.41	360.49	359.71	359.06	358.53	358.10	**357.76**	357.49	357.29	357.15	357.05	356.99
0.75	366.28	364.53	363.17	361.97	360.93	360.06	359.34	358.76	358.30	357.93	357.65	357.44	357.29	357.19	357.13	357.12
0.8	365.78	364.15	362.77	361.58	360.59	359.79	359.14	358.63	358.23	357.93	357.70	357.54	357.44	357.39	357.37	357.39
0.85	365.42	363.83	362.45	361.30	360.38	359.65	359.08	358.64	358.30	358.06	357.89	357.78	357.72	357.71	357.73	357.78
0.9	365.17	363.55	362.20	361.12	360.28	359.63	359.13	358.76	358.49	358.30	358.18	358.12	358.10	358.12	358.18	358.26
0.95	364.93	363.31	362.02	361.03	360.27	359.71	359.28	358.98	358.77	358.64	358.57	358.54	358.56	358.62	358.70	358.81
1	364.71	363.13	361.93	361.03	360.36	359.87	359.53	359.29	359.13	359.05	359.02	359.04	359.09	359.18	359.29	359.42

Sensitivity tests

The sensitivity of the assessment model results to assumptions and modelling decisions regarding fishery selection, natural mortality, maturity, recruitment variability, the form of the stock–recruit relationship and the nature of the SSB index (whether it was a relative or absolute index) was tested. Some of the sensitivity tests resulted from requests made during the Review Workshop (held in October 2016 in Santa Rosa, California). The Review Workshop was followed by a Training Workshop (12–14 October 2016, same venue), during which the baseline model was updated with data for 2014/15 and corrections made to the SSB index for 2012/13; results for this update were included as a sensitivity test.

Stochastic projections

Stochastic projections conditioned on the baseline assessment model were conducted to estimate MSY reference points and to explore the response of the stock to increasing harvest rates.

Operating model

An operating model conditioned on the baseline assessment was developed for the purpose of the evaluation of alternative simple harvest control rules. Thus, the operating model reflects the historic and current status of the stock as well as the associated uncertainty. The uncertainty was derived from the variance-covariance matrix (based on the delta-method in ADMB; Fournier *et al*. 2012). A matrix of 1000 parameter sets, including the stock and recruitment function parameters, was used to generate 1000 historic populations, which were then projected forward for 50 years under alternative management rules. The parameter sets were drawn from a multivariate normal distribution with means equal to the model parameter estimates and the variance-covariance matrix derived from the parameter correlations and standard deviations estimated in the assessment.

An issue encountered with the variance-covariance approach was that some of the drawn parameters fell outside the bounds specified in the assessment model (ASPM). A Markov chain Monte Carlo (MCMC) approach was therefore considered to incorporate assessment uncertainty, because this approach will only sample within the constraints. However, issues were also encountered with this method; the CVs of the MCMC drawn parameters were very high and there were large differences between the averages from MCMC sampling and the fitted model parameter estimates. In particular, the parameter estimates from the best fit often fell to the edge of MCMC parameter distributions that were highly skewed to the right. This behaviour is likely related to high correlations between the estimable parameters, and was considered unsatisfactory, because large parameter draws from MCMC sampling may lead to an underestimation of risk.

To overcome the issue of multivariate normal sampled parameters falling outside the bounds specified in the ASPM, 2000 sampled parameter sets were drawn and any sets containing one or more values falling outside of the bounds were rejected. Out of 2000 draws 1144 parameter sets were accepted. The first 1000 of these were used in the ASPM to obtain starting points for the stochastic projections. To justify this method of obtaining assessment uncertainty, the distributions from the full set of parameter draws were compared with the distributions of the truncated set (Appendix 4, Figure A4.1). The point estimates from the original assessment are included for comparison, and estimates of precision reflected by two standard deviations are also included as a check that input distributions are consistent with these uncertainty estimates from the original assessment. Apart from the bounded parameters which were truncated, the distributions were consistent with each other. Hence the multivariate normal runs were considered a reasonable characterisation of the assessment uncertainty.

Management strategy evaluations (MSE, Punt *et al.* 2016) were conducted using R (R Core Team, 2014). The assessment model was run without fitting for each of the 1000 input distributions and the numbers-at-age and spawning biomass for each population in 2013 were taken as the starting point for simulations (year 0 of the projections). Each population was projected forward into the following year using A2.1–A2.4 (Appendix 2). Recruitment in each year of the projection was modelled using A2.8 (Appendix 2) but with a breakpoint at the minimum biomass (prior to projections) for that population, giving a fixed hockey-stick stock–recruit formulation (see e.g. Figure A4.2).

Length of the projection period:
Forward projections under constant harvest rates were conducted to inform on the length of the projection period. A period of 50 years for forward projections was considered appropriate because the SSB stabilises after approximately 25 years under constant harvest rates (Figure 6). Therefore, performance statistics were computed for the last 20 years of the projections to ensure that the results were not influenced by starting conditions in the simulations.

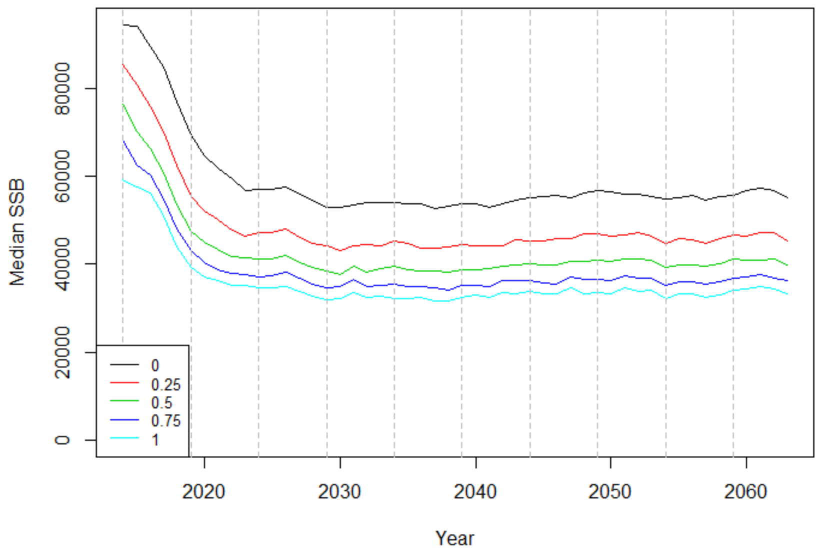

Figure 6 Forward 50-year projections under constant harvest rates: F = 0, 0.25, 0.5, 0.75 and 1.

Modelling recruitment:

It is essential to model future recruitment in a way that is consistent with what has been estimated for historic recruitment. Recruitment was generated on the basis of a fixed hockey-stick formulation (Appendix 2, A2.8-A2.10), where the SSB breakpoint was fixed at the lowest estimated SSB, and virgin recruitment (R_{virgin}) and serial correlation (□) were estimated based on the assessment (see Appendix 2, A2.32a for □). For the simulations, recruitment residuals were derived as described in Appendix 2 (A2.32b and subsequent text).

Figure A4.2 (Appendix 4) compares future recruitment generated with corresponding (i.e. based on the same SSB) historic recruitments and fixed hockey-stick fit, for a set of iterations. A combination of all populations and a cumulative recruitment distribution provides an overall comparison of historic (red) and corresponding future (black) recruitment (Figure A4.3, Appendix 4) and indicates that the approach followed provides a plausible basis for generating recruitment; therefore, it was adopted for subsequent work.

Mean weights, maturity, natural mortality and selection:

For the simulations, future weights at age were fixed equal to those measured in 2013 (Appendix 1, Table A1.4). Examination of the historic series suggest a slight decline in weight for ages 3 and older from 2000 on. The time-series for age 2 is noisier. The uncertainty in SSB may be marginally under-represented as a result of this assumption of fixed future weights.

Maturity values used for the assessment are shown in Table A1.2 (Appendix 1). Simulations assume that maturity will remain constant for future years at those values. Natural mortality M is assumed to be 0.53 per year (age- and year-invariant for ages 1 to 5) and is 1.95 for age 6 due to the application of $\square^{pgp}$ ($M_{y,6} \square \square^{pgp} M$; Table 4a). These assumptions are maintained for future years in the simulations.

Each population in future simulations has its own selection pattern with parameters drawn from the multivariate distributions shown in Appendix 4, Figure A4.1 (reflecting the uncertainty of the selection pattern from the 1998–2013 separable period of the baseline assessment), which remains constant going forward.

Converting the HCR into realised catch:
No implementation error is assumed. The TAC from the HCR is assumed to be fully taken, apart from cases where, at high exploitation levels, the TAC is set higher than the amount of fish available to the fishery, in which case the realised catch will be smaller than the TAC. A2.2 and A2.3 (Appendix 2) are used (replacing the catch tonnage C_y^f with the TAC, and capping the harvest rate F_y^f to be no greater than 1) to convert the TAC to a harvest rate by age, which is then implemented in the operating model (through A2.1, Appendix 2).

Performance statistics:
In order to evaluate the performance of the HCRs tested, a set of performance indicators was defined. The performance statistics used to evaluate the different HCRs were as follows:

Risk – average probability of Spawning Stock Biomass (B_y^{sp}) being below Blim, where the average is taken across the years of the projection periods.

$$\text{risk} = \frac{100}{N_{yr}} \sum_{y=1}^{N_{yr}} \left(\frac{\sum_{it=1}^{N_{iter}} I[B_{it,y}^{sp} < \text{Blim}]}{N_{iter}} \right)$$

where y indicates the year in the final 20 years of the projection period (N_{yr}=20), it the iteration number (N_{iter}=1000) and

$$I[B_{it,y}^{sp} < \text{Blim}] = \begin{cases} 1 & , B_{it,y}^{sp} < \text{Blim} \\ 0 & , B_{it,y}^{sp} \geq \text{Blim} \end{cases}$$

Mean SSB – median of the mean Spawning Stock Biomass of the projection period across iterations.

$$\text{Mean SSB} = P_{50}^{it}\left(\sum_{y=1}^{N_{yr}} B_{it,y}^{sp} / N_{yr} \right)$$

where y, N_{yr} and it are as above, and $P_{50}^{it}()$ calculates the median of the 1000 iterations.

Mean Yield – median of the mean of the total catch (C_y^f) for different projection periods across iterations.

$$\text{Mean Yield} = P_{50}^{it}\left(\sum_{y=1}^{N_{yr}} C_{it,y}^{f} / N_{yr} \right)$$

where y, N_{yr}, it and $P_{50}^{it}()$ are as above.

The harvest control rule

A harvest control rule (HCR) was defined where a pre-set fraction of the exploitable biomass (harvest rate F) can be taken when the SSB is greater than Bpa. This fraction is reduced linearly to zero when the SSB is less than Bpa:

$$TAC_y = \begin{cases} F\hat{B}_y^{ex} & , \hat{B}_y^{sp} \geq \text{Bpa} \\ F\hat{B}_y^{ex}\hat{B}_y^{sp}/\text{Bpa} & , \hat{B}_y^{sp} < \text{Bpa} \end{cases} \qquad (1)$$

where

$$\hat{B}_y^{ex} = \left(\sum_{a=0}^{a_{pg}} w_{a+\frac{1}{2}} S_a^f N_{y,a} e^{-M_a/2} \right) e^{\varepsilon_y}$$

and

$$\hat{B}_y^{sp} = B_y^{sp} e^{\varepsilon_y}$$

The quantities B_y^{sp}, $w_{a+\frac{1}{2}}$, S_a^f, $N_{y,a}$ and M_a are all taken from the operating model (note that the y subscript is no longer needed for selectivity and natural mortality because only the most recent selection pattern is used for the former, and the oil-spill factor is not used in projections for the latter), whereas the exploitable biomass $\hat{B}_y^{ex}$ and SSB $\hat{B}_y^{sp}$ are "perceived" quantities as a result of application of the assessment model. (In the simulations presented, the assessment model is not actually applied, but its application is approximated by adding assessment error, where ε_y above [same for perceived exploitable biomass and SSB] is taken from a normal distribution with mean zero and standard deviation 0.3.) One thousand 50-year-forward simulations were conducted to evaluate the HCRs proposed in terms of mediane recruitment, SSB and yields.

Results

From initial model to baseline model

Preliminary runs were carried out with the fixed hockey stick to initialize recruitment, with natural mortality fixed at 0.27 (which was the best estimate based on a likelihood profile), and allowing the model to estimate all selectivity parameters. This constituted the initial model (model 1 in Table 4a and Appendix 3). However, the approach resulted in domed selection for the commercial fleet (model 1 in Appendix 3, first "estimates" plot), and as a result, in an accumulation of older ages in the population, which appeared to be unrealistic. An additional concern was the oil spill in late 2007 that may have had a detrimental effect on San Francisco Bay herring (although it must be stressed that there is no direct evidence for this). Several trials were carried out to investigate these concerns.

(a) Oil spill factor

In order to address the potential effects of the oil spill on the herring population, a mortality factor ($\square^{oil}$) for the 2007/8 season, constant across all ages, was introduced (model 2 in Table 4a and Appendix 3). Introduction of this factor led to a significant improvement in model fit (compare $-\ln L$ for models 1 and 2 in Table 4a).

(b) Flat-topped commercial selectivity
Dome selection is estimated for both the commercial and research catches because there are fewer fish in the plus-group (fish aged 6 and older) than expected given the level of natural mortality M (Figure 7, model 1). Dome selection in commercial catches can imply a "cryptic" biomass, not seen by either the fishery or surveys, which nevertheless contributes towards production (through the SSB–recruit relationship), potentially making the stock resilient to fishing. Assuming flat-topped selection for at least one of the selectivity curves is one way of reducing problems introduced by cryptic biomass. Commercial catches were selected for mimicking flat-topped selection because Figure 7 (model 1) shows a stronger dome effect for research catches (predominantly trawl) than for commercial catches (gillnet in recent years).

To investigate the effect of flat-topped selection in the commercial catches, selectivity at age 6 was set equal to that at age 5 ($\square^{f}_{y,6} \square \square^{f}_{y,5}$) for both selectivity periods (1992–1997, 1998–2013). This is the only additional constraint imposed on model 1, resulting in model 3 (Table 4a) which has two fewer parameters than model 1 (one fewer selectivity parameter per selectivity period). Selectivity associated with research catches continued to be freely estimated, and continued to indicate dome selection (Figure 7, right plot).

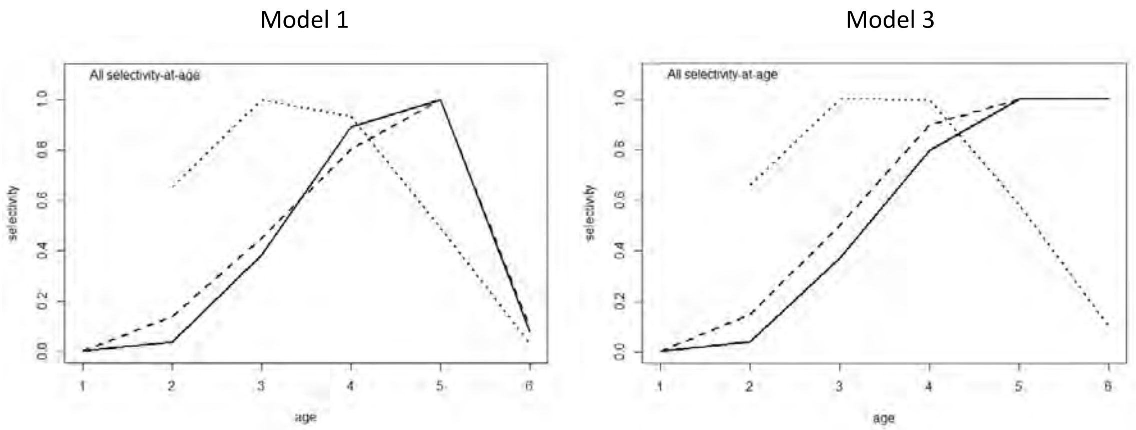

Figure 7 Selectivity-at-age for commercial (dashed = 1992–1997, solid = 1998–2013) and research (dotted) catches for models 1 and 3.

(c) Plus-group natural mortality
Another feature of model 3 is a strong deterioration in model fit (compare $-\ln L$ between models 1 and 3 in Table 4a, but also the poor fits to the commercial proportions-at-age data in Appendix 3 for model 3). This is because the model expects to see many more plus-group (age 6) fish than are available in the data, given M and flat-topped selection. One way around this is to introduce a multiplicative factor, $\square^{pgp}$, which can be applied to age 6 (Appendix 2). This factor does not necessarily indicate additional natural mortality, but could indicate that the older fish disappear from the area, for example. With the introduction of $\square^{pgp}$, model 4 shows a significant improvement in fit relative to model 3

(Table 4a), with a large improvement in the fits to the commercial proportions-at-age data (Appendix 3, model 4).

Model 5 combines (a)–(c), showing a significant improvement in model fit over model 4 (Table 4a). However, the M value is still the same as model 1 (M=0.27), and has not been optimized (in likelihood terms) for this model configuration. In order to do so, a likelihood profile over M was performed, indicating a minimum negative log-likelihood at M=0.53 (Figure 8). This is adopted as the M value for model 6 (Table 4a, Appendix 3). In order to better facilitate comparisons with models 1–4, these latter models were re-run for M=0.53, with results shown in Table 4b (models 1b–4b, along with model 6).

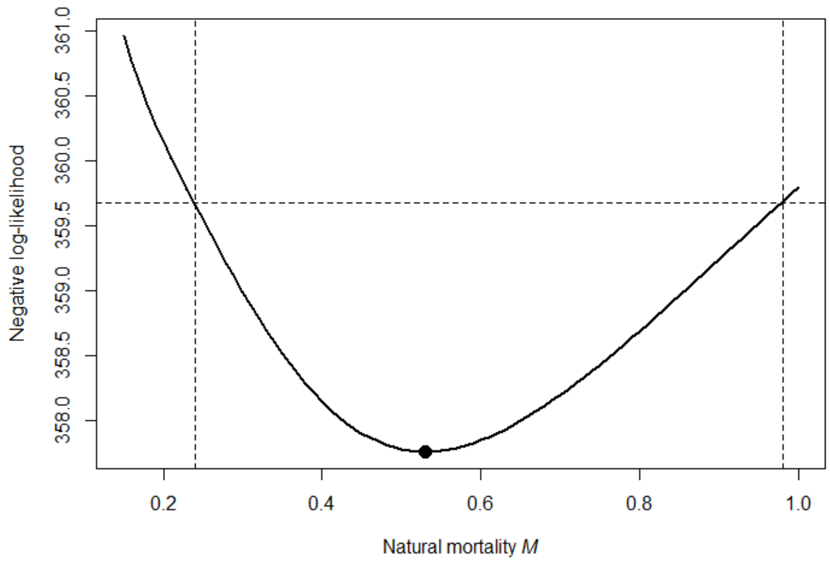

Figure 8 Likelihood profile for natural mortality (M), model 5/6 in Table 4a. Best M=0.53; 95% confidence intervals (minimum function value+1.92): 0.24 – 0.98.

Table 4a. Key model outputs for model 1: the initial model; model 2: model 1 + multiplicative factor ($\square^{oil}$) for M in 2007; model 3: model 1 + flat topped selection in the commercial fishery (by setting $\square^{f}_{y,6} \square\square^{f}_{y,5}$); model 4: model 3 + multiplicative factor ($\square^{pgp}$) for M at age 6; model 5: model 4 + $\square^{oil}$; and model 6: the baseline model, which is model 5 but with $\square$ fixed at 0.53 (as shown in Figure 7). Values in parentheses are CVs (standard deviation over mean).

Settings/Parameters/Diagnostics	**Initial Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Baseline Model 6**
Settings						
2007 M factor, $\square^{oil}$		✓			✓	✓
Age 6 M factor, $\square^{pgp}$				✓	✓	✓
Flat topped commercial selectivity (set $\square^{f}_{y,6} \square\square^{f}_{y,5}$)			✓	✓	✓	✓
M obtained by likelihood profile (optimum value)	✓					✓
Input parameters						
M	0.27	0.27	0.27	0.27	0.27	0.53
$\square_R$	0.7	0.7	0.7	0.7	0.7	0.7
p_{virgin}	0.75	0.75	0.75	0.75	0.75	0.75
Estimated general parameters						
K^{sp}	64162 (0.19)	46218 (0.14)	31670 (0.10)	84448 (0.42)	56964 (0.24)	74370 (0.23)
R_{virgin}	228433 (0.19)	164549 (0.14)	112754 (0.10)	461683 (0.42)	308786 (0.25)	861149 (0.23)
$\square^{oil}$	-	5.898 (0.23)	-	-	2.415 (0.26)	2.614 (0.23)
$\square^{pgp}$	-	-	-	9.769 (0.10)	8.076 (0.14)	3.676 (0.14)
Recruitment serial correlation $\square$	0.715 (0.038)	0.722 (0.072)	0.705 (0.064)	0.704 (0.060)	0.729 (0.058)	0.739 (0.059)
Estimated constant of proportionality parameters						
SSB index $q^{s=ssb}$	0.583 (0.27)	1.024 (0.19)	1.358 (0.11)	0.367 (0.49)	0.612 (0.31)	0.449 (0.28)
Recruitment index $q^{s=rec}$	1.264 (0.22)	1.654 (0.16)	2.219 (0.11)	0.625 (0.46)	0.952 (0.27)	0.336 (0.26)
Estimated variability parameters						
SSB index $v^{s\square ssb}_{adv}$	0.722 (0.15)	0.758 (0.16)	0.754 (0.15)	0.662 (0.15)	0.650 (0.15)	0.617 (0.16)
Recruitment index $v^{s\square rec}_{adv}$	0.634 (0.16)	0.707 (0.17)	0.696 (0.16)	0.623 (0.16)	0.640 (0.16)	0.672 (0.17)
Commercial proportions $\square^{f}_{p}$	0.122 (0.062)	0.113 (0.048)	0.236 (0.033)	0.142 (0.041)	0.133 (0.047)	0.135 (0.042)
Research proportions $\square^{s}_{p}$	0.106 (0.086)	0.112 (0.072)	0.102 (0.045)	0.095 (0.059)	0.100 (0.068)	0.097 (0.060)
Likelihood contributions						
Total (-ln$L$)	**355.81**	**349.85**	**437.97**	**363.38**	**359.32**	**357.76**
SSB index	24.10	25.16	25.05	22.19	21.81	20.67
Recruitment index	20.30	22.56	22.23	19.94	20.48	21.52
Commercial proportions	223.07	213.51	306.54	242.27	234.66	236.62
Research proportions	62.95	67.65	59.94	53.78	57.79	55.24
Stock-recruit	25.39	20.96	24.21	25.21	24.58	23.71
Other diagnostics						
Estimable parameters	39	40	37	38	39	39
Maximum gradient component	3.511e-5	6.679e-5	5.096e-5	7.256	2.790e-5	5.961e-5

Table 4b. As for Table 4a, but M is set equal to 0.53 for all models. [Note, model 5 is not repeated because model 6 is in effect model 5 with M=0.53.]

Settings/Parameters/Diagnostics	Initial Model 1b	Model 2b	Model 3b	Model 4b	Baseline Model 6
Settings					
2007 M factor, $\square^{oil}$		✓			✓
Age 6 M factor, $\square^{pgp}$				✓	✓
Flat topped commercial selectivity (set $\square^{f}_{y,6} \square\square^{f}_{y,5}$)			✓	✓	✓
M obtained by likelihood profile (optimum value)					✓
Input parameters					
M	0.53	0.53	0.53	0.53	0.53
$\square_R$	0.7	0.7	0.7	0.7	0.7
p_{virgin}	0.75	0.75	0.75	0.75	0.75
Estimated general parameters					
K^{sp}	97278 (0.36)	74068 (0.19)	44751 (0.13)	143316 (0.74)	74370 (0.23)
R_{virgin}	1002020 (0.36)	762938 (0.19)	460963 (0.31)	1671320 (0.74)	861149 (0.23)
$\square^{oil}$	-	2.942 (0.25)	-	-	2.614 (0.23)
$\square^{pgp}$	-	-	-	4.627 (0.11)	3.676 (0.14)
Recruitment serial correlation $\square$	0.708 (0.060)	0.750 (0.057)	0.708 (0.057)	0.693 (0.065)	0.739 (0.059)
Estimated constant of proportionality parameters					
SSB index $q^{s=ssb}$	0.318 (0.44)	0.490 (0.25)	0.737 (0.12)	0.198 (0.82)	0.449 (0.28)
Recruitment index $q^{s=rec}$	0.292 (0.41)	0.385 (0.22)	0.603 (0.12)	0.169 (0.79)	0.336 (0.26)
Estimated variability parameters					
SSB index $v_{adv}^{s\square ssb}$	0.641 (0.15)	0.638 (0.16)	0.641 (0.15)	0.625 (0.15)	0.617 (0.16)
Recruitment index $v_{adv}^{s\square rec}$	0.629 (0.16)	0.697 (0.17)	0.670 (0.16)	0.620 (0.16)	0.672 (0.17)
Commercial proportions $\square_p^f$	0.135 (0.043)	0.131 (0.041)	0.190 (0.036)	0.144 (0.039)	0.135 (0.042)
Research proportions $\square_p^s$	0.095 (0.058)	0.096 (0.058)	0.097 (0.051)	0.093 (0.055)	0.097 (0.060)
Likelihood contributions					
Total (-ln$L$)	**357.54**	**353.96**	**402.38**	**362.69**	**357.76**
SSB index	21.50	21.40	21.49	20.95	20.67
Recruitment index	20.14	22.26	21.43	19.82	21.52
Commercial proportions	236.64	232.44	279.46	244.81	236.62
Research proportions	53.67	54.18	55.08	52.10	55.24
Stock-recruit	25.60	23.67	24.92	25.00	23.71
Other diagnostics					
Estimable parameters	39	40	37	38	39
Maximum gradient component	8.066e-5	9.445e-5	2.215e-5	8.453e-5	5.961e-5

Baseline model

Model 6 was adopted as the baseline model in this study (Table 4a). This was based on the difficulty in justifying the cryptic biomass present in models 1 and 2, which was reduced by the introduction of flat-topped commercial selection and plus-group mortality factor, $\square^{pgp}$ (to counteract the deterioration in fit caused by forcing flat-topped selection), and the fact that inclusion of the oil spill factor, $\square^{oil}$, for 2007 significantly improved the overall model fit.

Model fits and residuals:

Model fits to the SSB and recruitment indices are shown in Figure 9. The fit to the SSB index is acceptable, although the model is still unable to follow some of the rapid year-to-year changes in the index. Variability in the survey index is large given factors such as environmental conditions, predation, variability in temporal and spatial spawning activity that would influence the survey estimates (Spratt 1976, Watters and Oda 1997), which are not factored into the assessment model. However, we agree with MacCall *et al.* (2003) in their assessment review that the spawning survey should be the primary abundance estimate for stock assessment. Similar considerations regarding variability apply to the fit to the recruitment index. No obvious residual patterns are apparent.

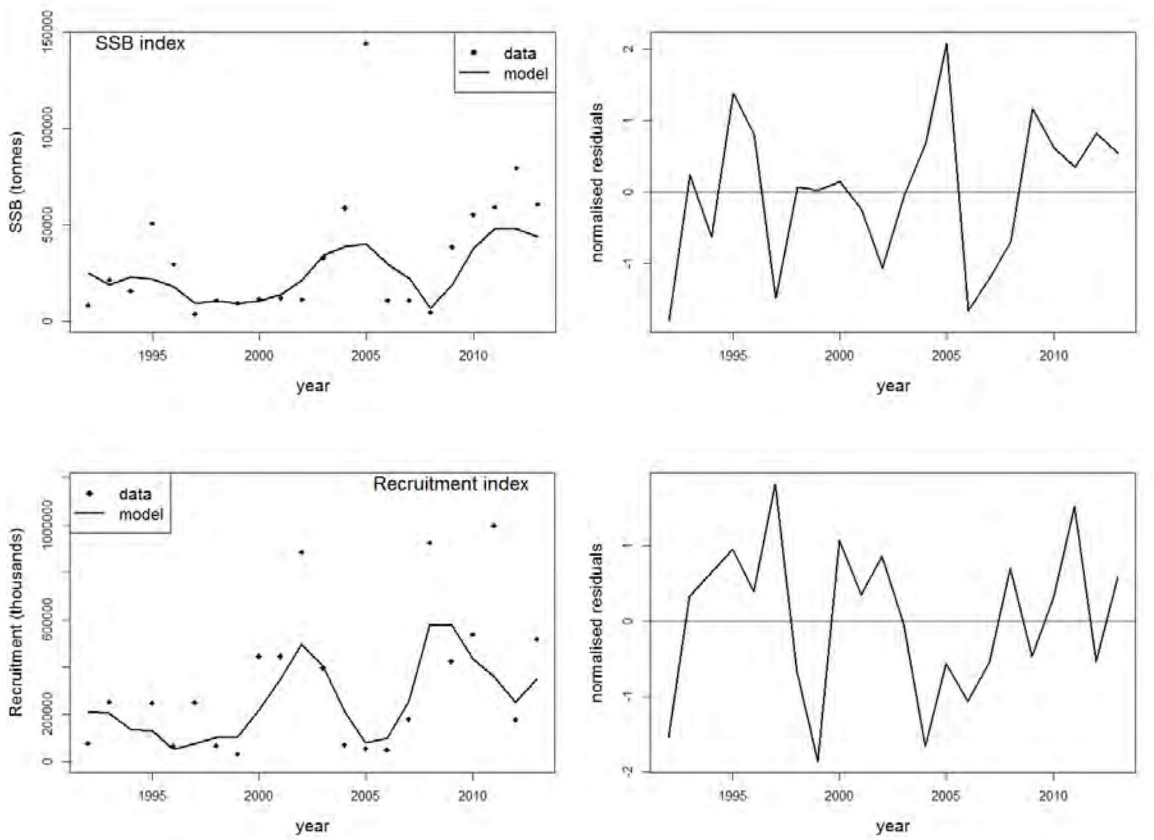

Figure 9 Baseline model 6 fits to the SSB (top) and Recruitment (bottom) indices, with model fits to the data on the left and residual plots on the right. The normalized residuals are $L^{s}_{U,nres}(y)$ (Appendix 2, A2.27).

Fits to the commercial and research catch-at-age data, expressed as proportions-at-age, are shown in Figure 10. Model averages agree well with the data averages (left plots in Figure 10). Although some residual patterns are evident in the case of the commercial catch-at-age, those have been reduced by the assumption of two separable periods. The SSB–recruitment pairs are shown in Figure 11, together with residuals from the stock-recruit fit (see Appendix 2, A2.8). The residual patterns indicate the presence of auto-correlation (estimated at □= 0.739, Table 4a).

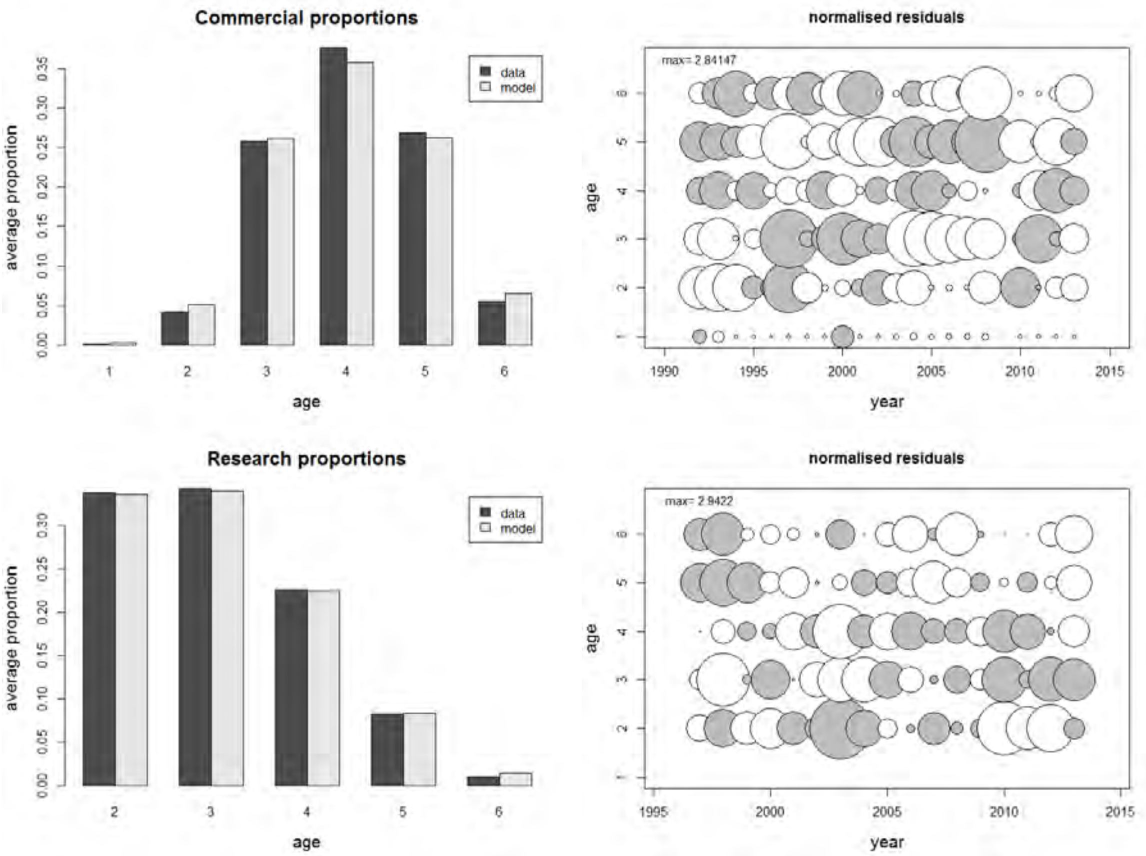

Figure 10 Baseline model 6 fits to the Commercial (top) and Research (bottom) catch-at-age data, with model fits on the left (shown as average over the period for which data are available) and residual bubble plots on the right. In the bubble plots white bubbles indicate negative residuals, and grey bubbles positive; furthermore, the area of bubbles is proportional to the size of the residual, and the “max” value indicated in the top left of the plot relates to the maximum absolute value of residuals shown in the plot (i.e. the size of the largest bubble). The normalized residuals are $L^{j}_{p,nres}(y,a)$ (Appendix 2, A2.29).

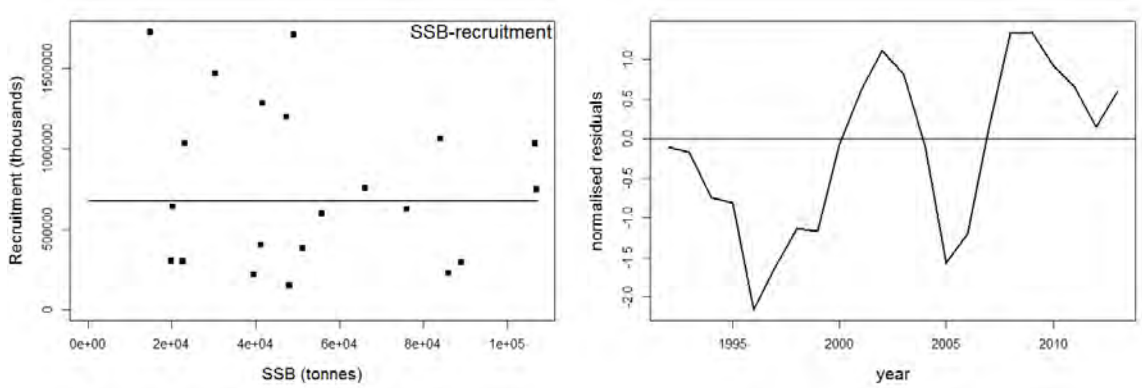

Figure 11 Baseline model 6: SSB-recruitment pairs with stock–recruit relationship estimated by the simple stock–recruit form (Appendix 2, A2.8) and corresponding residuals (right). The normalized residuals are $L_{R,nres}(y)$ (Appendix 2, A2.31), but note □is set to zero for the estimation (so $L_{R,nres}(y)$ □□$_y$ /□$_R$), and only calculated after the model fit (via Appendix 2, A2.32a).

Model estimates:

Figure 12 provides estimates of population trends with confidence intervals estimated as ±2 standard deviations (approximately 95% confidence limits). The stock biomass seems to have recovered after low recruitment in 2005/06 and the potentially detrimental effects of the oil spill in late 2007. Uncertainty is, however, large in recent years. The harvest rate is estimated to be low in the recent period.

Retrospective plots corresponding to Figure 12 are shown in Figure 13. These are obtained by “shaving” off one year of data at a time and re-running the assessment; this was done for five years. These retrospective plots show reasonably good behaviour, with retrospective curves well within the 95% confidence limits. SSB has a slight tendency for under-estimation, which is more pronounced for recruitment.

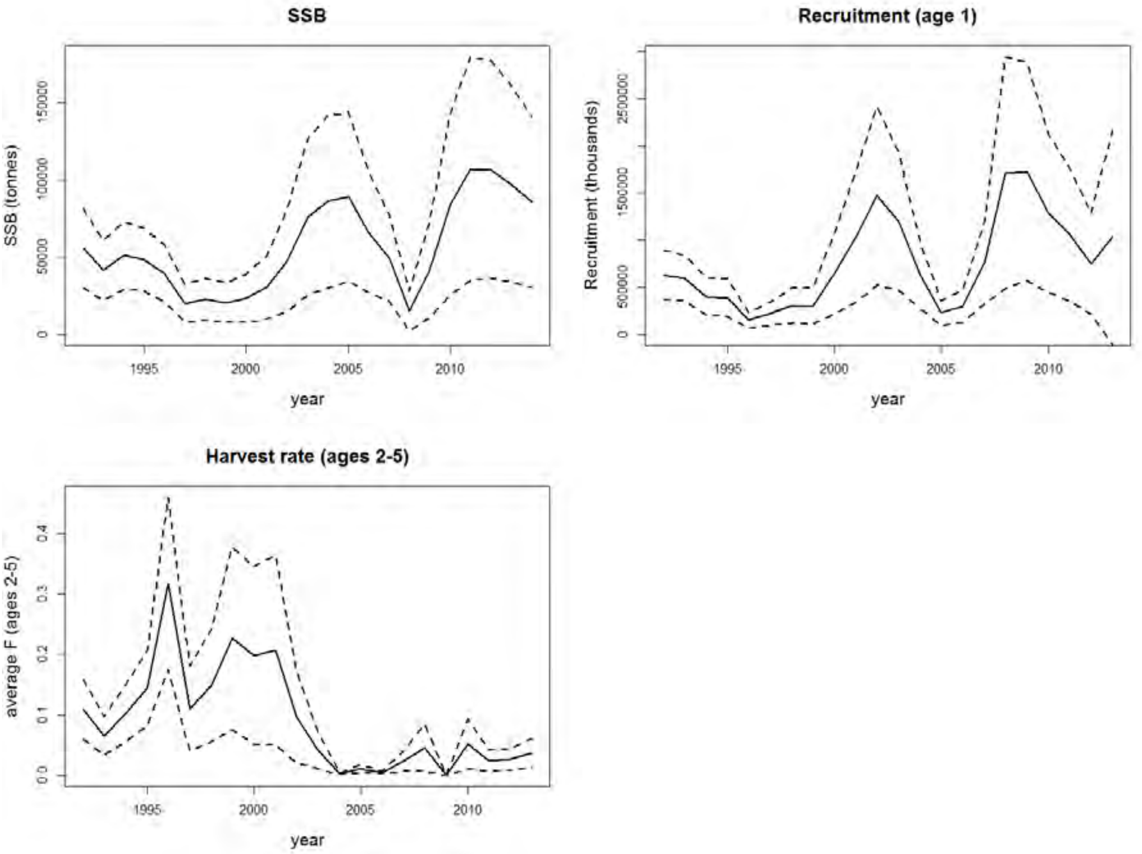

Figure 12 Baseline model 6 population estimates with ± 2 standard deviations: SSB (top left) in tonnes, Recruitment at age 1 in thousands (top right) and harvest rate F averaged over ages 2–5 (bottom). [Note, the SSB plot includes one more year than the others.]

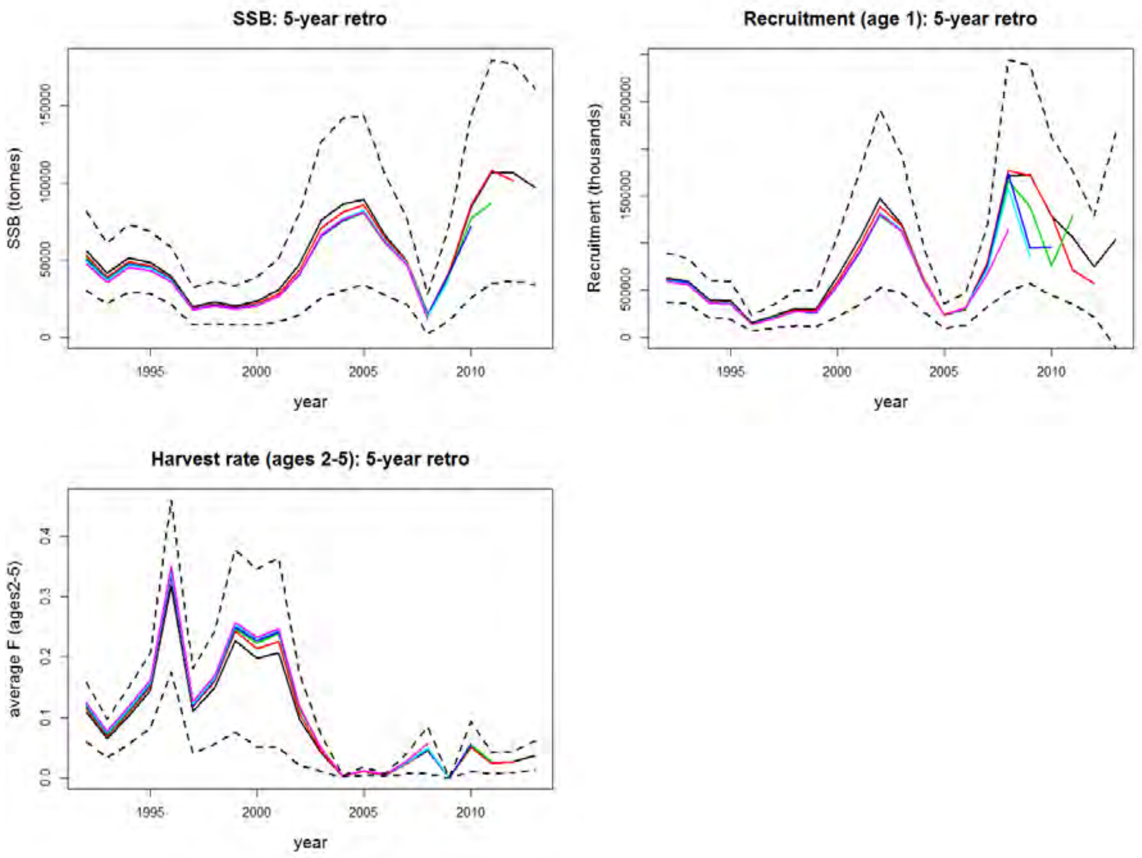

Figure 13 Baseline model 6 five-year retrospective plots corresponding to Figure 12. [Note, the SSB plot has one less year than the corresponding curve in Figure 12, so that only years for which data exist are shown.]

Estimates of the commercial and research catch selectivity curves are provided in Figure 14. The numbers of plus-group age 6 fish in the research catch are very low relative to the numbers expected by the model, so selection is estimated to be rather low for this age group.

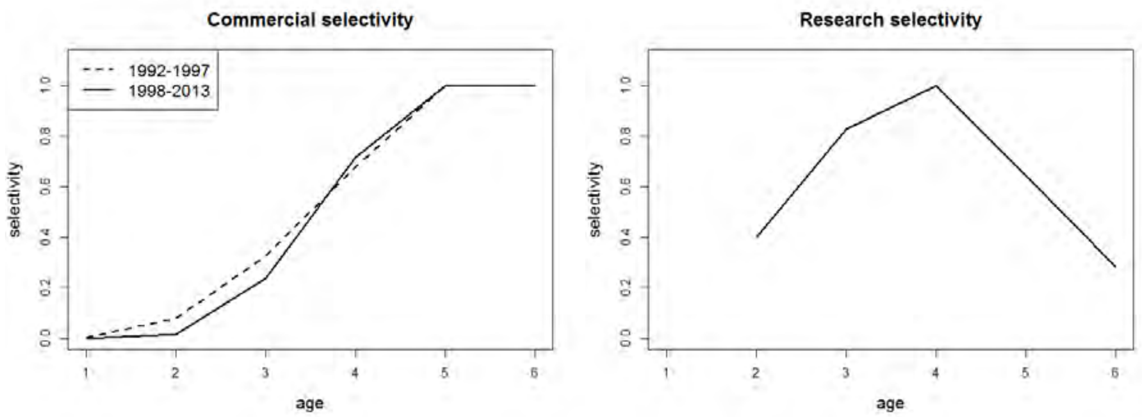

Figure 14 Baseline model 6 estimates of selectivity-at-age for commercial (left) and research catches (right). Two separable periods were fitted to the commercial data, where the dashed line corresponds to the period 1992-1997 and the solid line corresponds to fishery selectivity for 1998-2013.

Sensitivity tests

Results from sensitivity tests relative to fishery selection, natural mortality, maturity, recruitment variability, the form of the stock–recruit relationship and the nature of the SSB index (whether it was a relative or absolute index) are presented in the following sections.

Fishery selection:

The baseline model (model 6) only accounts for a commercial selectivity change between 1997 and 1998. However, apart from the cessation of round-haul catches in 1998, there was also a mesh-size reduction, implemented from 2004 on, for commercial catches, and these sensitivity runs attempted to account for this change and to assess its impact. Model 7 shifts the selectivity change to between 2003 and 2004 (ignoring the earlier change between 1997 and 1998). This leads to a deterioration in model fit, and much greater uncertainty in model outputs relative to the baseline model (Table 5). Model 8 includes both changes (i.e. between 1997 and 1998, and between 2003 and 2004), where the selectivity in the period between these two changes (covering the years 1998–2003) is modelled as a linear interpolation between the selectivity of the first period (1992–1997) and that of the last period (2004–2013). There is a slight deterioration in model fit relative to the baseline model, and parameters (particularly those dealing with scale) are less precisely estimated (Table 5). Model 9 optimizes model 8 for M (through likelihood profiling), resulting in an increase in M from 0.53 to 0.64; although the model fit is slightly improved, precision of estimated parameters deteriorates slightly, and both elements (model fit and precision) are slightly worse than the baseline model (Table 5). There was therefore no justification for changing the baseline model.

Table 5 Key model outputs for sensitivity runs investigation commercial selectivity. Model 6: baseline model (see Table 4a); model 7: model 6 but selectivity period change occurs in 2003–2004 instead of 1997–1998; model 8: model 6 but with three selectivity periods, the first 1992–1997, the third 2004–2013, and the second a linear interpolation between the first and third; model 9: model 8 but with □ fixed at 0.64 (optimum value based on a likelihood profile). Values in parenthesis are CVs.

Settings/Parameters/Diagnostics	**Baseline Model 6**	**Model 7**	**Model 8**	**Model 9**
Settings				
Selectivity periods	1992-1997 1998-2013	1992-2003 2004-2013	1992-1997 linear interpolation 2004-2013	1992-1997 linear interpolation 2004-2013
M obtained by likelihood profile (optimum value)	✓			✓
Input parameters				
M	0.53	0.53	0.53	0.64
$□_R$	0.7	0.7	0.7	0.7
p_{virgin}	0.75	0.75	0.75	0.75
Estimated general parameters				
K^{sp}	74370 (0.23)	119727 (0.72)	74762 (0.29)	94128 (0.32)
R_{virgin}	861149 (0.23)	1389550 (0.73)	864627 (0.29)	1459840 (0.33)
$□^{oil}$	2.614 (0.23)	2.452 (0.25)	2.830 (0.24)	2.649 (0.22)
$□^{pgp}$	3.676 (0.14)	3.925 (0.14)	3.559 (0.15)	2.940 (0.14)
Recruitment serial correlation □	0.739 (0.059)	0.718 (0.068)	0.750 (0.058)	0.748 (0.060)
Estimated constant of proportionality parameters				
SSB index $q^{s=ssb}$	0.449 (0.28)	0.253 (0.82)	0.459 (0.37)	0.351 (0.40)
Recruitment index $q^{s=rec}$	0.336 (0.26)	0.195 (0.77)	0.339 (0.35)	0.199 (0.36)
Estimated variability parameters				
SSB index $v_{adv}^{s□ssb}$	0.617 (0.16)	0.628 (0.16)	0.616 (0.16)	0.610 (0.16)
Recruitment index $v_{adv}^{s□rec}$	0.672 (0.17)	0.642 (0.17)	0.669 (0.17)	0.676 (0.17)
Commercial proportions $□_p^f$	0.135 (0.042)	0.138 (0.043)	0.136 (0.042)	0.137 (0.041)
Research proportions $□_p^s$	0.097 (0.060)	0.098 (0.063)	0.097 (0.060)	0.096 (0.059)
Likelihood contributions				
Total (-ln$L$)	**357.76**	**359.58**	**358.03**	**357.83**
SSB index	20.67	21.05	20.65	20.41
Recruitment index	21.52	20.55	21.42	21.63
Commercial proportions	236.62	239.09	236.90	237.75
Research proportions	55.24	56.34	55.52	54.67
Stock-recruit	23.71	22.56	23.54	23.36
Other diagnostics				
Estimable parameters	39	39	39	39
Maximum gradient component	5.961e-5	3.141e-5	4.634e-5	3.506e-5

Natural mortality:

Natural mortality is assumed to be constant by age and over time, apart from mortality factors in 2007 ($□^{oil}$) and for plus-group age 6 ($□^{pgp}$). The former is because of the possibility that the oil spill in late 2007 may have had a detrimental effect on herring in San Francisco Bay, and the latter because plus-group age 6 fish are less abundant in both the commercial and research catches than expected for a natural mortality of around 0.5, under the assumption that the commercial selectivity is flat-topped (based on commercial selectivity considerations).

Excluding the 2007 mortality factor ($\square^{oil}$) leads to significantly poorer model fits in likelihood terms (compare e.g. model 4 to model 5 in Table 4a), to higher estimates of M when selecting M based on profiling the likelihood (0.73 for model 4 [results not shown] compared with 0.53 for model 5), and to substantially greater model uncertainty. Even though there is no direct evidence for the detrimental effect the oil spill may have had on herring mortality, the inclusion of $\square^{oil}$ significantly improves the model fit and reduces model uncertainty; $\square^{oil}$ was therefore kept. It should be noted that the cohorts that would have been affected by this mortality factor are no longer present in the population.

Tanasichuk (1999) uses a particular formulation for estimating natural mortality-at-age, namely:

$$M_a \;\square\; \alpha e^{\square a}$$

where α and $\square$ are parameters, and *a* represents age. The values for α and $\square$ estimated by Tanasichuk for adult Pacific herring off southern British Columbia were 0.14 and 0.18 respectively, and hypothesise increasing natural mortality with age for adult fish. In order to check whether this approach could deal with the high natural mortality factor the model needs for plus-group age 6 in order to fit the data, two additional sensitivity runs were performed where α and $\square$ were estimated (by simultaneously profiling the likelihood over these parameters) with (model 10) and without (model 11) the plus-group age 6 mortality factor ($\square^{pgp}$; Table 6). It is clear from these results that omitting $\square^{pgp}$ leads to unrealistically low estimates of natural mortality for ages 1–3, and a high natural mortality for plus-group age 6 still results, so introducing the Tanasichuk formulation for M does not solve the need for a high natural mortality for plus-group age 6. The simpler formulation of M=0.53 with a higher natural mortality for plus-group age 6 (through application of $\square^{pgp}$) was therefore kept. Model outputs for the three models (6, 10 and 11) are given in Table 7 (along with two other models dealing with M discussed below)

Table 6 Natural mortality for the baseline model 6, and for two versions of the Tanasichuk (1999) formulation (one with $\square^{pgp}$, and one without).

	1	2	3	4	5	6
Baseline model 6	0.53	0.53	0.53	0.53	0.53	1.95
Model 10: Tanasichuk with $\square^{pgp}$ (α=0.25, $\square$=0.18)	0.30	0.36	0.43	0.51	0.61	1.81
Model 11: Tanasichuk without $\square^{pgp}$ (α=0.03, $\square$=0.67)	0.06	0.11	0.22	0.44	0.86	1.67

Table 7 Key model outputs for sensitivity runs investigating alternative natural mortality formulations. Model 6: baseline model (see Table 4a); model 10: model 6, but natural mortality follows the Tanasichuk formulation, including $\square^{pgp}$; model 11: model 10, but excluding $\square^{pgp}$; model 12: model 6, but M is directly estimated (instead of being fixed or obtained by likelihood profile); model 13: model 6, but excluding $\square^{pgp}$. Models 12 and 13 were requested as part of the Review Workshop. Values in parentheses are CVs.

Settings/Parameters/Diagnostics	**Baseline Model 6**	**Model 10**	**Model 11**	**Model 12**	**Model 13**
Settings					
Tanasichuk formulation for M		✓	✓		
$\square^{pgp}$ included	✓	✓			
M estimated (i.e. not fixed are obtained by likelihood profile)				✓	
Input parameters					
M	0.53	Table 6	Table 6	0.530 (0.30)	0.53
$\square_R$	0.7	0.7	0.7	0.7	0.7
p_{virgin}	0.75	0.75	0.75	0.75	0.75
Estimated general parameters					
K^{sp}	74370 (0.23)	67350 (0.21)	64821 (0.19)	74367 (0.37)	45478 (0.12)
R_{virgin}	861149 (0.23)	507089 (0.21)	274280 (0.19)	861079 (0.76)	468448 (0.12)
$\square^{oil}$	2.614 (0.23)	2.962 (0.24)	2.675 (0.18)	2.614 (0.24)	3.892 (0.18)
$\square^{pgp}$	3.676 (0.14)	2.452 (0.15)	-	3.676 (0.34)	-
Recruitment serial correlation $\square$	0.739 (0.059)	0.734 (0.056)	0.711 (0.053)	0.739 (0.059)	0.724 (0.076)
Estimated constant of proportionality parameters					
SSB index $q^{s=ssb}$	0.449 (0.28)	0.502 (0.26)	0.511 (0.23)	0.449 (0.44)	0.812 (0.11)
Recruitment index $q^{s=rec}$	0.336 (0.26)	0.573 (0.23)	1.061 (0.22)	0.337 (0.78)	0.558 (0.12)
Estimated variability parameters					
SSB index $v_{adv}^{s\square ssb}$	0.617 (0.16)	0.620 (0.16)	0.621 (0.15)	0.617 (0.16)	0.648 (0.16)
Recruitment index $v_{adv}^{s\square rec}$	0.672 (0.17)	0.663 (0.16)	0.636 (0.16)	0.672 (0.17)	0.767 (0.17)
Commercial proportions $\square_p^f$	0.135 (0.042)	0.136 (0.042)	0.138 (0.041)	0.135 (0.045)	0.180 (0.030)
Research proportions $\square_p^s$	0.097 (0.060)	0.096 (0.059)	0.094 (0.057)	0.097 (0.064)	0.095 (0.048)
Likelihood contributions					
Total (-ln$L$)	**357.76**	**357.41**	**358.08**	**357.76**	**393.30**
SSB index	20.67	20.79	20.82	20.67	21.73
Recruitment index	21.52	21.23	20.37	21.52	24.27
Commercial proportions	236.62	236.89	238.68	236.62	272.53
Research proportions	55.24	54.33	52.56	55.24	53.32
Stock-recruit	23.71	24.18	25.65	23.71	21.45
Other diagnostics					
Estimable parameters	39	39	38	39	38
Maximum gradient component	5.961e-5	9.779e-5	4.675e-5	7.193e-5	2.811e5

Additional sensitivity tests (conducted during review):

A number of additional sensitivity tests were requested during the Review Workshop. These related to natural mortality (models 12 and 13), increased age 2 maturity (model 14), stronger flat-topped commercial selectivity (model 15), increased recruitment variability (model 16), a change to Beverton–Holt stock-recruit formulation (model 17) and forcing the constant of proportionality for the SSB index to be 1. These are discussed below and model outputs shown in Tables 7 and 8.

(a) Estimate natural mortality M
Instead of M being a fixed input (which could be derived by likelihood profiling), model 12 treats M as an estimable parameter. Not surprisingly, estimating M leads to almost the same model outputs (because M was originally derived by likelihood profiling, and then treated as a fixed input), but also increases model uncertainty substantially (estimates of precision deteriorate markedly for a number of model estimates; Table 7).

(b) Omit estimation of the plus-group mortality factor ($\square^{pgp}$)
Omitting the estimation of $\square^{pgp}$ (model 13) leads to the same result seen previously (compare models 1 and 3 in Table 4a and Appendix 3), namely that the model is not able to fit the older age groups in the commercial proportions-at-age data (note the deterioration in $-\ln L$ compared to baseline model 6 shown in Table 7, and particularly the component associated with commercial proportions).

(c) Increase age 2 maturity from 0.36 to 0.60
Apart from some re-scaling, the increase in age 2 maturity (model 14) has a negligible impact on model fits (Table 8), although it is more difficult to compare model fits because of the change in underlying data. However, this change will have an impact on model projections, because it means that a greater proportion of the population matures earlier compare to the commercial selectivity. This topic is discussed in more detail later.

(d) Force stronger flat-topped commercial selectivity ($\square^{f}_{y,6} \square\square^{f}_{y,5} \square\square^{f}_{y,4}$)
Forcing a stronger flat-topped commercial selectivity (by setting $\square^{f}_{y,6} \square\square^{f}_{y,5} \square\square^{f}_{y,4}$ for model 15, instead of only $\square^{f}_{y,6} \square\square^{f}_{y,5}$ for baseline model 6) leads to a significant deterioration in model fit and a substantial increase in population scale (Table 8).

(e) Increase recruitment variability ($\square_R$) from 0.7 to 1.0
An increase in recruitment variability to $\square_R$ =1.0 for model 16 (instead of 0.7 for the baseline model 6) is not warranted on model-fitting considerations (it is outside the 95% confidence region shown in Table 3); there is a deterioration in model fit (compare $-\ln L$ for models 6 and 16) due to the larger stock–recruit residuals that result (Table 8).

(f) Change the stock–recruit model to Beverton–Holt
A change in the stock–recruit model from the simple stock–recruit formulation (baseline model 6; Appendix 2, A2.8) to a Beverton–Holt formulation (model 17; Appendix 2, A2.5-A2.7) leads to a very similar model fit and estimates (Table 8), but the steepness parameter h for model 17 is not well estimated (the estimate runs into the bound set at h=0.99; Table 8). The fits are compared in Figure 15).

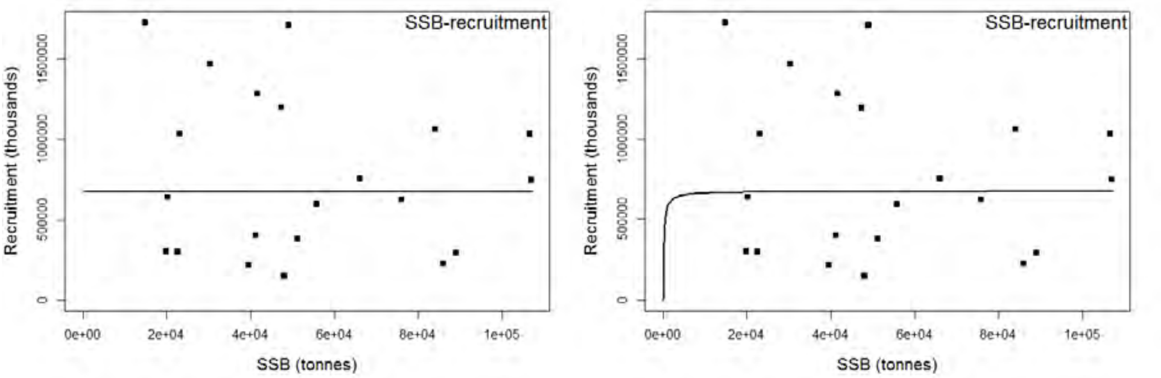

Figure 15 Stock–recruit fits for the simple stock-recruit curve (baseline model 6, left) and the Beverton–Holt curve (model 17, right)

(g) Force the constant of proportionality parameter for the SSB index ($q^{s=ssb}$) to be 1
Forcing the constant of proportionality for the SSB index to be 1 ($q^{s=ssb}$ =1) implies the SSB index is an absolute index of abundance (model 19). As expected, this leads to a deterioration in model fit, which is significant (compare models 6 and 18 in Table 8), because the model forces the parameter away from its maximum likelihood value; the population is also re-scaled.

Table 8 Key model outputs for sensitivity runs investigating a series of alternative model settings, as requested during the Review Workshop. Model 6: baseline model (see Table 4a); model 14: increase age 2 maturity to 0.6; model 15: force stronger commercial flat-top selection (by forcing the final 3 ages to be equal); model 16: increase recruitment variability to 1; model 17: change to a Beverton–Holt stock–recruit model; model 18: force the SSB index to have a constant of proportionality of 1 (instead of estimating it). Grey cells indicate the feature that has changed compared to the baseline model 6. Note, model 14 is not strictly comparable to the other models because the underlying maturity data has changed. Values in parentheses are CVs.

Settings/Parameters/Diagnostics	**Baseline Model 6**	**Model 14**	**Model 15**	**Model 16**	**Model 17**	**Model 18**
Settings						
Age 2 maturity	0.36	0.60	0.36	0.36	0.36	0.36
Flat-topped commercial selection: ages forced to be equal	last 2 ages	last 2 ages	last 3 ages	last 2 ages	last 2 ages	last 2 ages
Stock-recruit model	simple	simple	simple	simple	Bev-Holt	simple
Input parameters						
M	0.53	0.53	0.53	0.53	0.53	0.53
$\square_R$	0.7	0.7	0.7	1.0	0.7	0.7
p_{virgin}	0.75	0.75	0.75	0.75	0.75	0.75
Estimated general parameters						
K^{sp}	74370 (0.23)	79849 (0.22)	582440 (3.54)	84387 (0.22)	74412 (0.23)	55818 (0.12)
R_{virgin}	861149 (0.23)	841521 (0.22)	6773120 (3.54)	978143 (0.22)	h=0.99* (0.004)	641708 (0.12)
$\square^{oil}$	2.614 (0.23)	2.700 (0.22)	1.894 (0.26)	2.422 (0.23)	2.613 (0.23)	3.296 (0.18)
$\square^{pgp}$	3.676 (0.14)	3.620 (0.14)	4.176 (0.13)	3.781 (0.13)	3.676 (0.14)	3.100 (012)
Recruitment serial correlation $\square$	0.739 (0.059)	0.740 (0.059)	0.690 (0.071)	0744 (0.060)	0.739 (0.059)	0.723 (0.070)
Estimated constant of proportionality parameters						
SSB index $q^{s=ssb}$	0.449 (0.28)	0.408 (0.26)	0.048 (3.63)	0.452 (0.25)	0.449 (0.28)	1
Recruitment index $q^{s=rec}$	0.336 (0.26)	0.347 (0.24)	0.040 (3.59)	0.346 (023)	0.336 (0.26)	0.503 (0.11)
Estimated variability parameters						
SSB index $v_{adv}^{s\square ssb}$	0.617 (0.16)	0.611 (0.16)	0.642 (0.16)	0.615 (0.16)	0.617 (0.16)	0.748 (0.16)
Recruitment index $v_{adv}^{s\square rec}$	0.672 (0.17)	0.676 (0.17)	0.639 (0.17)	0.664 (0.17)	0.672 (0.17)	0.711 (0.17)
Commercial proportions $\square_p^f$	0.135 (0.042)	0.135 (0.042)	0.149 (0.036)	0.135 (0.041)	0.135 (0.042)	0.135 (0.40)
Research proportions $\square_p^s$	0.097 (0.060)	0.097 (0.060)	0.092 (0050)	0096 (0.061)	0.097 (0.060)	0.099 (0.059)
Likelihood contributions						
Total (-ln$L$)	**357.76**	**357.49**	**365.01**	**359.02**	**357.76**	**363.16**
SSB index	20.67	20.45	21.54	20.60	20.67	24.87
Recruitment index	21.52	21.63	20.46	21.27	21.52	22.70
Commercial proportions	236.62	236.46	248.46	236.11	236.62	236.65
Research proportions	55.24	55.31	50.87	54.72	55.22	56.94
Stock-recruit	23.71	23.63	23.69	26.32	23.73	22.00
Other diagnostics						
Estimable parameters	39	39	37	39	40	39
Maximum gradient component	5.961e-5	4.296e-5	7.345e-5	1.429e-5	5.839e-5	5.208e-5

*This value is not R_{virgin} but h (because this is a Beverton–Holt model; see Appendix 2, A2.5-A2.7) which hits the bound of 0.99 on estimation

Update of baseline assessment (conducted during the training workshop):
The baseline assessment model was updated with two more years of data during the Training Workshop (held 12–14 October immediately after the Review Workshop). This section presents the updated assessment (model 19; Figures 16-22 and Table 9). Apart from two more years of data, corrections were also made to the SSB index for the years 2012 (79509 tons was changed to 77002 tons) and 2013 (60626 tons was changed to 57428 tons). The updates have led to a higher profile likelihood estimate of M (Figure 16, Table 9), and an up-scale of the population as a result (Table 9). The retrospective under-estimation of SSB is slightly more pronounced (compare Figures 13 and 21), but the series of positive residual for recent SSB index values (leading to a perception of model misfit of recent SSB index values; Figure 9) is no longer continued with the addition of two more years of data (Figure 17).

The Training Workshop gave the opportunity for participants to carry out further sensitivity tests, and one of the issues that arose was how relatively insensitive the model was to changes in the SSB and recruitment indices. This can be seen from the variability parameters, which give the proportion-at-age data lower variances and hence greater weight in the model fit compared with the SSB and recruitment indices (Table 9).

Likelihood profile:

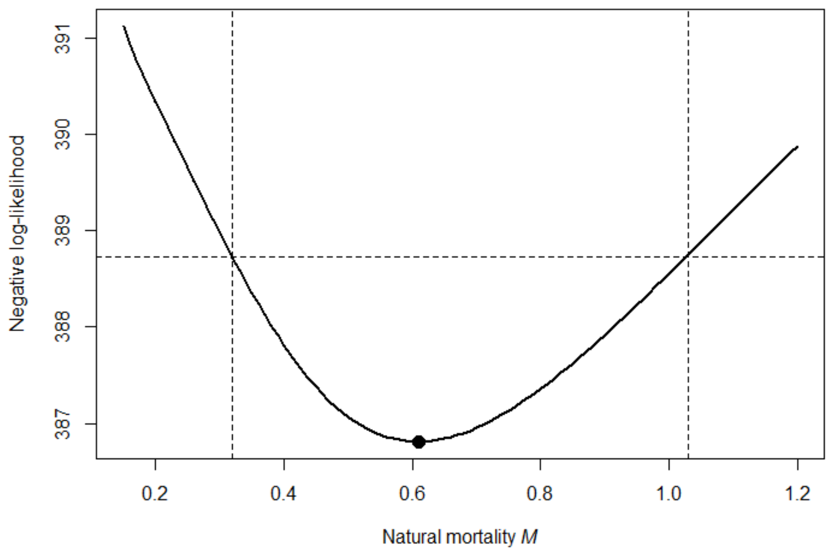

Figure 16 Updated model 19 likelihood profile for natural mortality (M). Best M=0.61; 95% confidence intervals (minimum function value+1.92): 0.32 – 1.03.

Model fits and residuals:

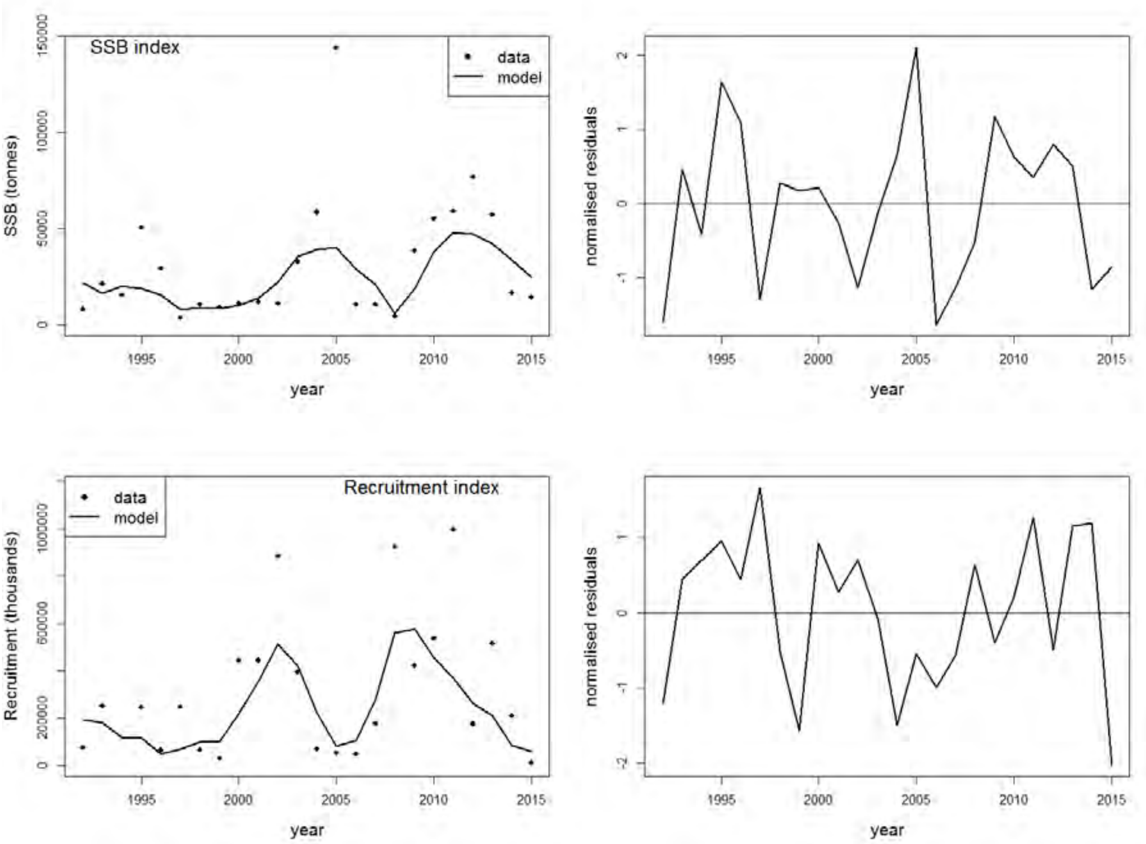

Figure 17 Updated model 19 fits to the SSB (top) and Recruitment (bottom) indices, with model fits to the data on the left and residual plots on the right. The normalized residuals are $L^{s}_{U,nres}(y)$ (Appendix 2, A2.27).

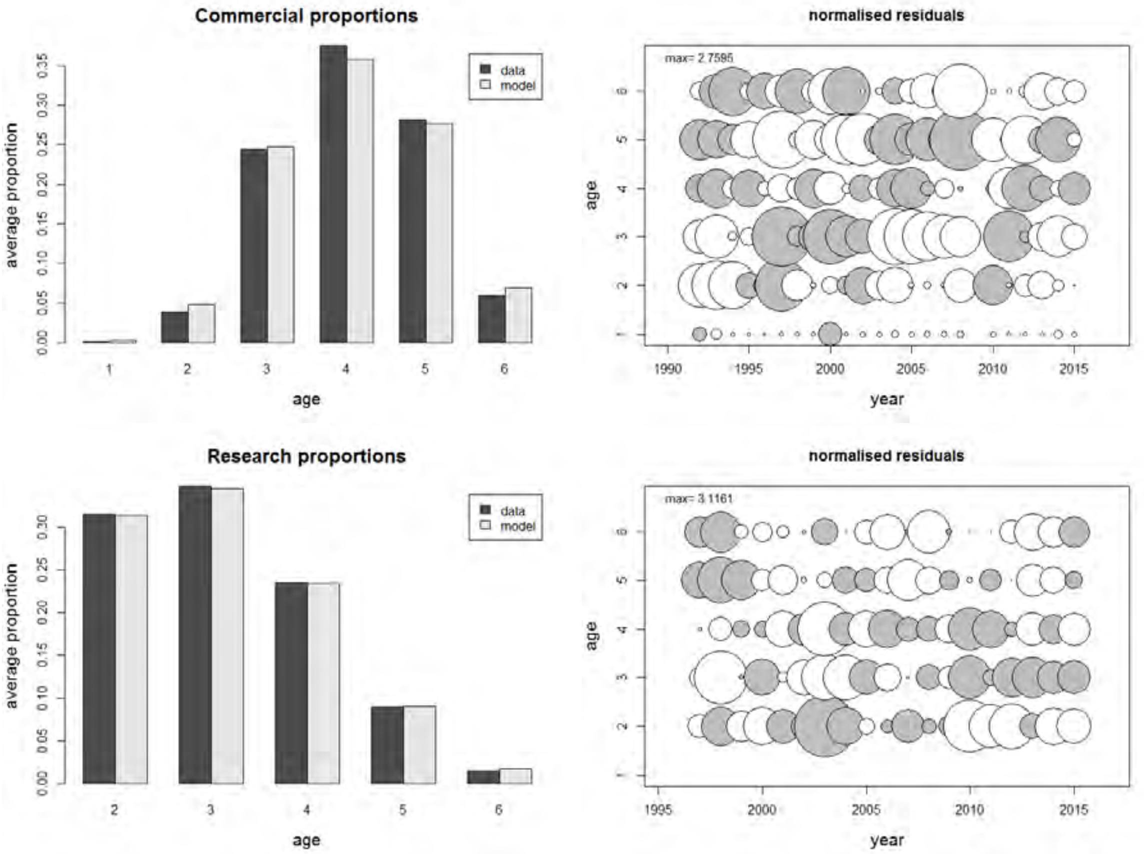

Figure 18 Updated model 19 fits to the Commercial (top) and Research (bottom) catch-at-age data, with model fits on the left (shown as average over the period for which data are available) and residual bubble plots on the right. In the bubble plots white bubbles indicate negative residuals, and grey bubbles positive; furthermore, the area of bubbles is proportional to the size of the residual, and the "max" value indicated in the top left of the plot relates to the maximum absolute value of residuals shown in the plot (i.e. the size of the largest bubble). The normalized residuals are $L^{j}_{p,nres}(y,a)$ (Appendix 2, A2.29).

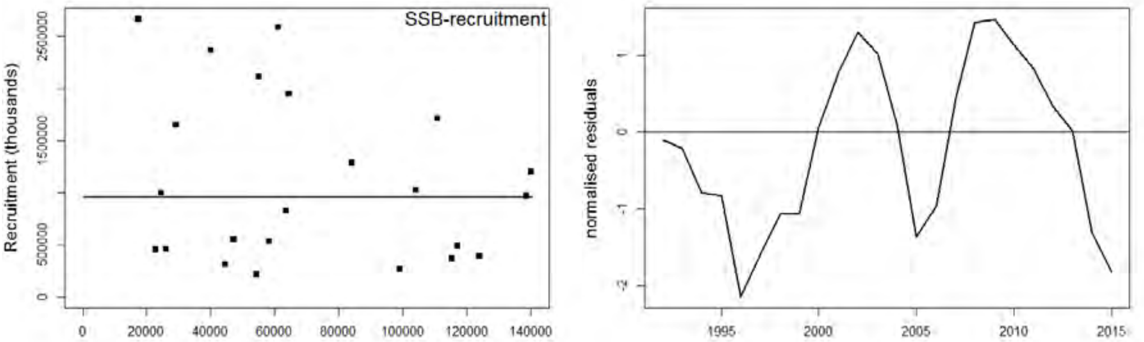

Figure 19 Updated model 19 fits: SSB-recruitment pairs with stock-recruit relationship estimated by the simple stock-recruit form (Appendix 2, A2.8) and corresponding residuals (right). The normalized residuals are $L_{R,nres}(y)$ (Appendix 2, A2.31), but note □is set to zero for the estimation (so $L_{R,nres}(y) \square \square_y / \square_R$), and only calculated after the model fit (via Appendix 2, A2.32a).

Model estimates:

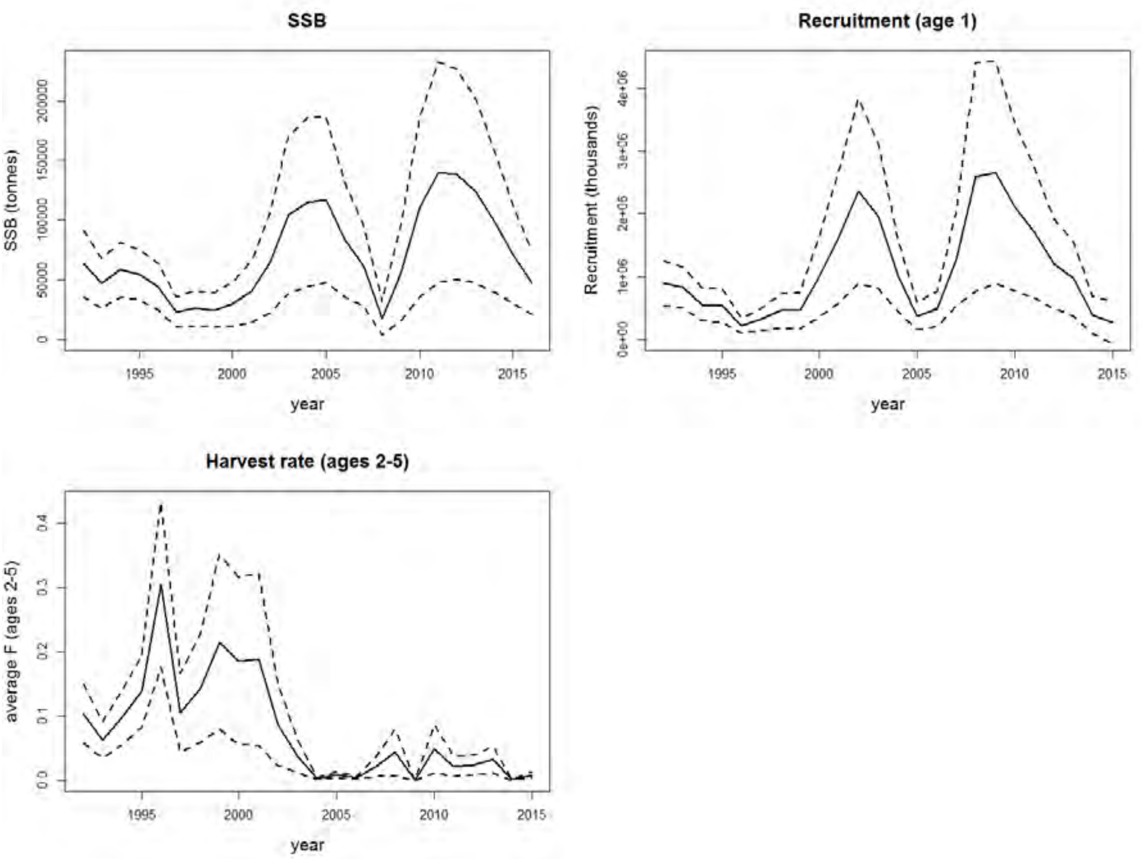

Figure 20 Updated model 19 population estimates with ± 2 standard deviations: SSB (top left) in tonnes, Recruitment at age 1 in thousands (top right) and harvest rate F averaged over ages 2–5 (bottom). [Note, the SSB plot includes one more year than the others.]

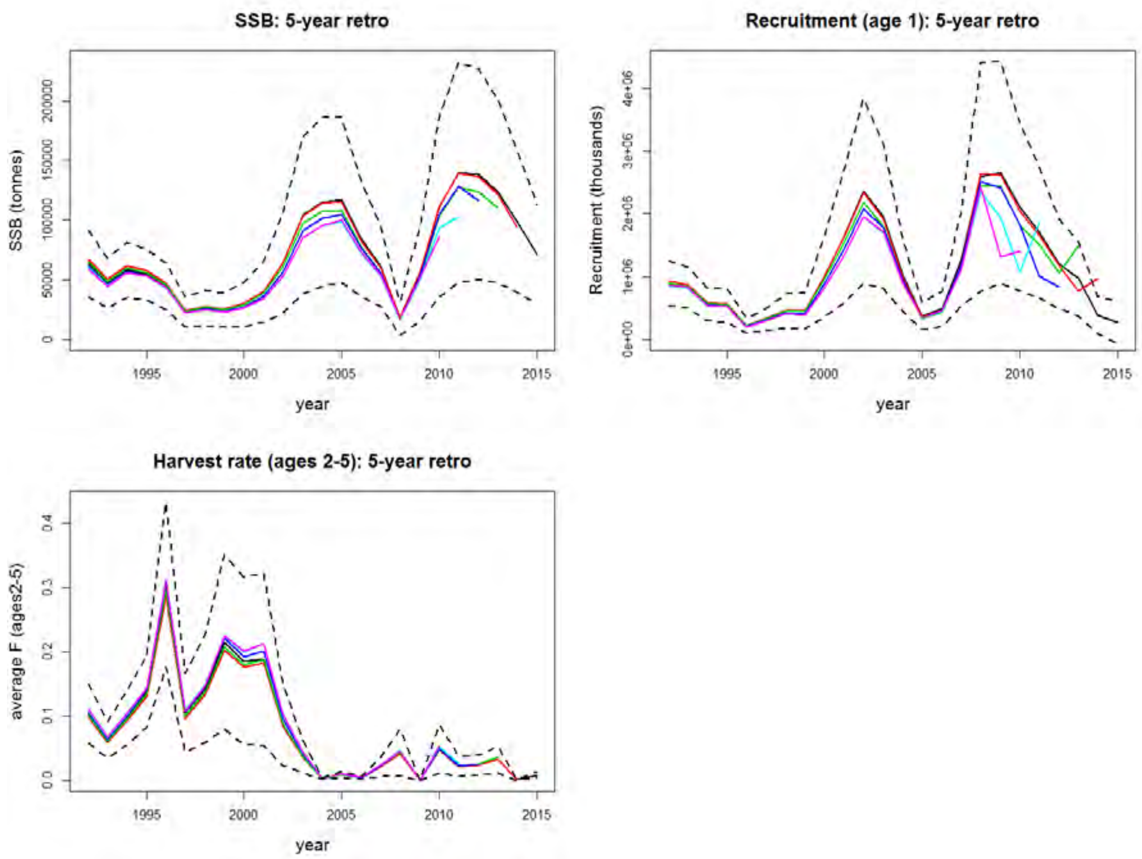

Figure 21 Updated model 19 five-year retrospective plots corresponding to Figure 20. [Note, the SSB plot has one less year than the the corresponding curve in Figure 20, so only the years for which data exist are shown.]

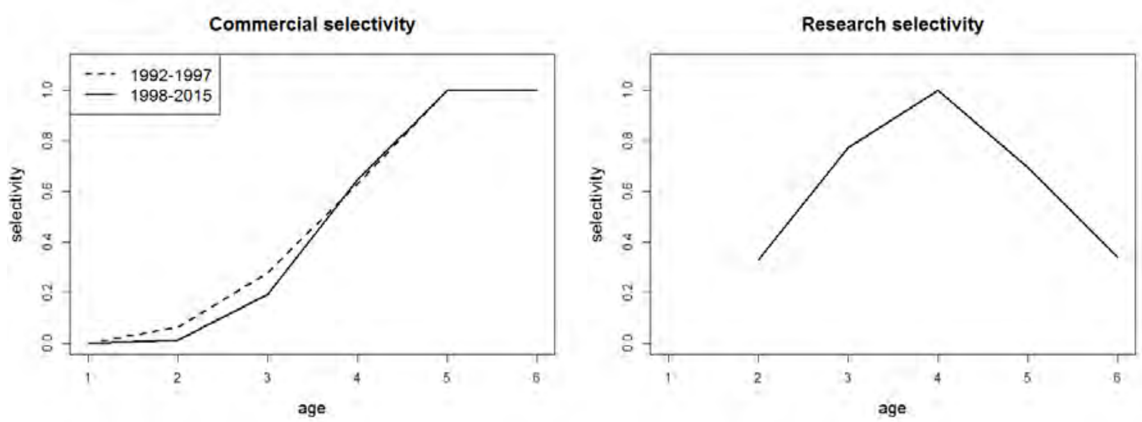

Figure 22 Updated model 19 estimates of selectivity-at-age for commercial (left) and research catches (right). Two separable periods were fitted to the commercial data, where the dashed line corresponds to the period 1992–1997 and the solid line corresponds to fishery selectivity for 1998–2015.

Table 9 Key model outputs for the baseline model 6, and an update of this model (model 19) to account for 2014/15 data, and a correction to the 2012/13 SSB indices). Note, models 6 and 19 are not strictly comparable because the underlying data have changed. Values in parenthesis are CVs.

Settings/Parameters/Diagnostics	**Baseline Model 6**	**Updated Model 19**
Settings		
Data changes	Data up to 2013	Data up to 2015 Update of SSB index 2012-2013 values
M obtained by likelihood profile	✓	✓
Input parameters		
M	0.53	0.61
□$_R$	0.7	0.7
p_{virgin}	0.75	0.75
Estimated general parameters		
K^{sp}	74370 (0.23)	84799 (0.22)
R_{virgin}	861149 (0.23)	1217850 (0.22)
□^{oil}	2.614 (0.23)	2.621 (0.20)
□^{pgp}	3.676 (0.14)	3.231 (0.12)
Recruitment serial correlation □	0.739 (0.059)	0.751 (0.035)
Estimated constant of proportionality parameters		
SSB index $q^{s=ssb}$	0.449 (0.28)	0.341 (0.27)
Recruitment index $q^{s=rec}$	0.336 (0.26)	0.216 (0.25)
Estimated variability parameters		
SSB index $v_{adv}^{s□ssb}$	0.617 (0.16)	0.608 (0.15)
Recruitment index $v_{adv}^{s□rec}$	0.672 (0.17)	0.780 (0.17)
Commercial proportions □$_p^f$	0.135 (0.042)	0.132 (0.038)
Research proportions □$_p^s$	0.097 (0.060)	0.095 (0.055)
Likelihood contributions		
Total (-ln$L$)	**357.76**	**386.81**
SSB index	20.67	22.18
Recruitment index	21.52	26.96
Commercial proportions	236.62	255.86
Research proportions	55.24	54.15
Stock-recruit	23.71	27.67
Other diagnostics		
Estimable parameters	39	41
Maximum gradient component	5.961e-5	3.884e-5

Reference points

Stochastic projections were carried out using the baseline assessment (model 6) in order to facilitate the estimation of MSY reference points. These projections were set up in the same way as the operating model (see description below). Precautionary reference points were also needed for the development of the harvest control rules (HCRs) themselves and in order to facilitate the evaluation of these harvest control rules. The most important reference point is the limit reference point Blim, defined as the stock size below which there may be reduced reproduction leading to reduced recruitment (ICES 2016a). ICES guidelines on developing reference points (ICES 2016b) were used to define Blim, taken as the lowest SSB in the time series for the baseline assessment (Blim = Bloss = 14 830 tonnes), because there is no evidence from the stock–recruit plot of impaired recruitment for higher SSB values (Figure 11). Blim is used in the definition of risk (average probability that SSB falls below Blim, where the average of the annual probabilities is taken across the projected years; as in risk1, ICES 2013a, risk definitions).

Consideration of a precautionary safety margin, incorporating assessment uncertainty, leads to another reference point, the precautionary approach reference point Bpa; this is a biomass reference point designed to avoid reaching Blim, such that when SSB is above Bpa, the probability of impaired recruitment is expected to be low (ICES 2016a). In most cases, the safety margin used to define Bpa is a standard value such that Bpa =1.4 Blim; this approach has been used for San Francisco Bay herring, given Bpa = 20 762 tonnes. Bpa is used in the construction of HCRs (see below).

Long-term stochastic projections were conducted to estimate MSY reference points. The historic populations were projected forward 50 years under constant harvest rates (F) to estimate equilibrium yield and SSB and corresponding confidence intervals for a range of F values (0 to 1 in steps of 0.05). Median catch and SSB were derived from the results for the last 20 years of the projections. Equilibrium yields and SSB for a range of F values between 0 and 1 are shown in Figure 23. The two upper panels correspond to the fishery selectivity estimated in the assessment. The yield curve on the upper left plot increases continuously as F increases while SSB declines only slightly. This is the result of fishing mortality only having an impact on the older year classes while mature younger fish are only partially affected by the fishery (Figure 24). The lower two plots in Figure 23 illustrate the results of implementing full selectivity (all age classes are fully selected by the commercial gear) indicating that in that case, yields would be maximised at F = 0.3 with a 46% associated risk.

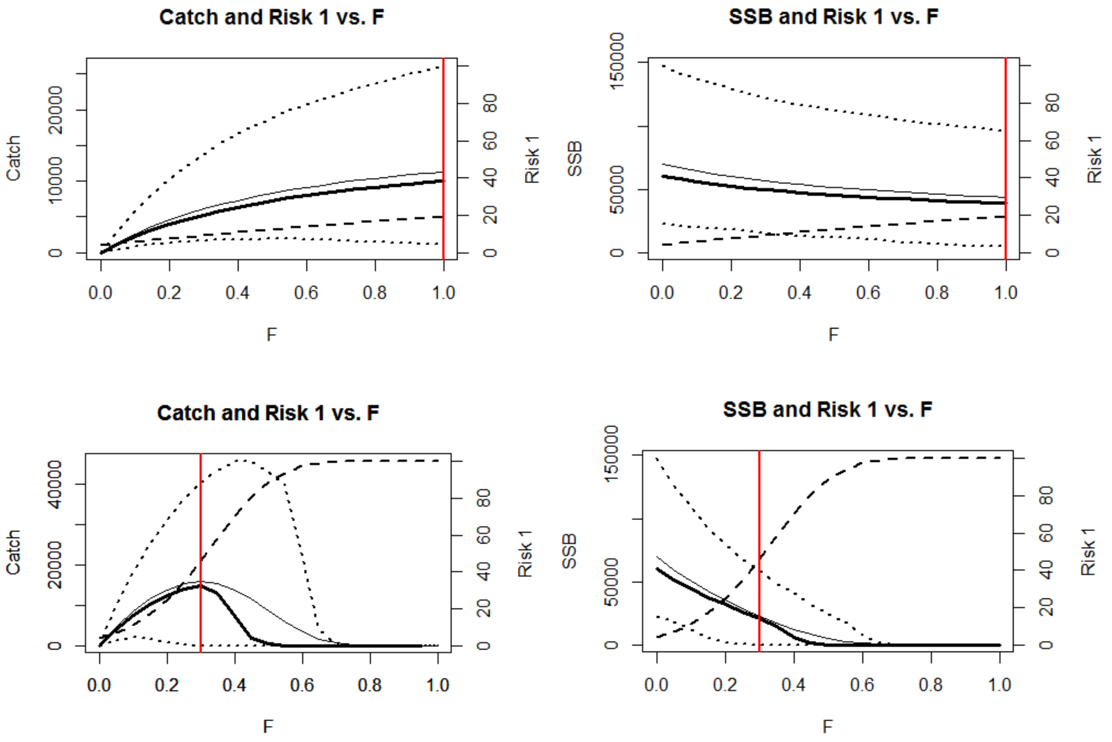

Figure 23 Average catch (left) and SSB (right) distributions, and associated average risk of SSB dropping below Blim = 14 830 t, indicated by the black bold hashed curve (same for left and right plots) for the final 20 years of 50-year long-term stochastic projection. For the upper plots, fishery selectivity as estimated by the baseline model 6, whereas for the lower plots knife-edge selectivity is assumed. The solid, bold black curve is the median, the solid light black curve the mean, and the dotted black curves the 5th and 95th percentiles. The red vertical lines are the same on the left and right-hand plots, with the solid red bold line representing the peak of the median catch curve on both plots.

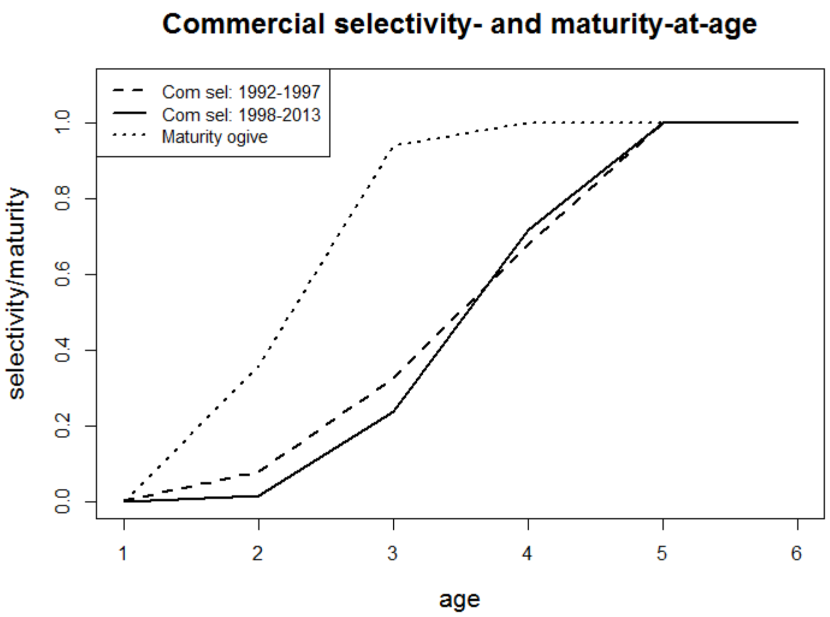

Figure 24 A repeat of Figure 14 for baseline model 6, but superimposing the maturity ogive in the plot.

Initial evaluation of the harvest control rule

The results of one thousand 50-year-forward simulations conducted to evaluate the HCRs proposed in terms of recruitment, SSB and catch for a range of F values (0, 0.25. 0.5. 0.75, 1) are shown in Figure 25a. A set of individual trajectories are included in the plots for comparison with the median. Performance statistics for the set of HCRs evaluated are shown in Table 10.

Examination of the results presented in the first column of Figure 25a (impact on recruitment) suggests that the increase in exploitation has little impact. This is partly because of the implementation of the HCR, which protects the stock by reducing catch when the biomass is low, but also because of the fishery selectivity, which allows a large fraction of mature age classes to survive the fishery (Figure 24).

The initial reduction in SSB (Figure 25a, 2nd column), even under zero F, is due to the stock coming off high SSB levels around 2010; average recruitment thereafter could no longer sustain a high SSB. As F increases, SSB stabilises at a lower level and this is primarily the result of fishing, not of reduced recruitment. Although the median SSB is well above Blim in all cases, the uncertainty in SSB is large, as reflected by the confidence intervals. The 5th percentile of the SSB distribution is below Blim when the stock is fished at or above a harvest rate of F = 0.25 (Figure 25a, 2nd column).

In order to place the simulation results in a historic context, Figure 25b compares the projections for F = 0.25 (for illustrative purposes) with the baseline assessment estimates/observations. These plots indicate reasonable consistency between assessment estimates of SSB and recruitment, and the corresponding values produced in the simulation projections. Recent catches have been lower than F = 0.25, so it is not surprising that an HCR with a harvest rate target of F = 0.25 leads to higher catches than observed.

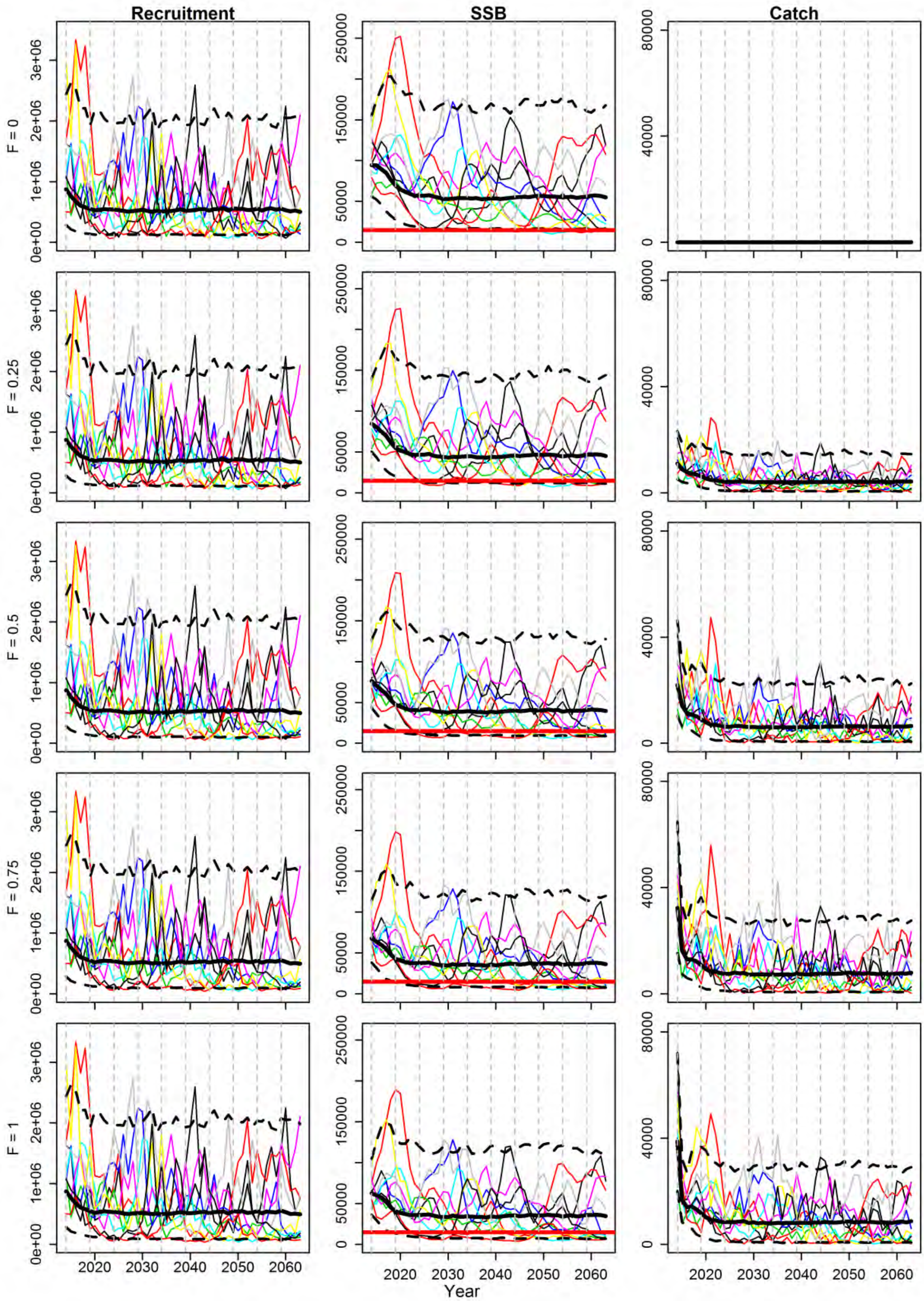

Figure 25a Results from 50-year-forward projections for F values ranging from 0 to 1 in steps of 0.25 (top to bottom row). Median recruitment, SSB and catch of simulated trajectories (solid black line). A few trajectories are shown (coloured lines) as well as 90% confidence intervals (hashed black lines). The solid horizontal red line in the SSB plots represents Blim (=14 830t), which can be compared with the 5th percentile (used in the risk calculation).

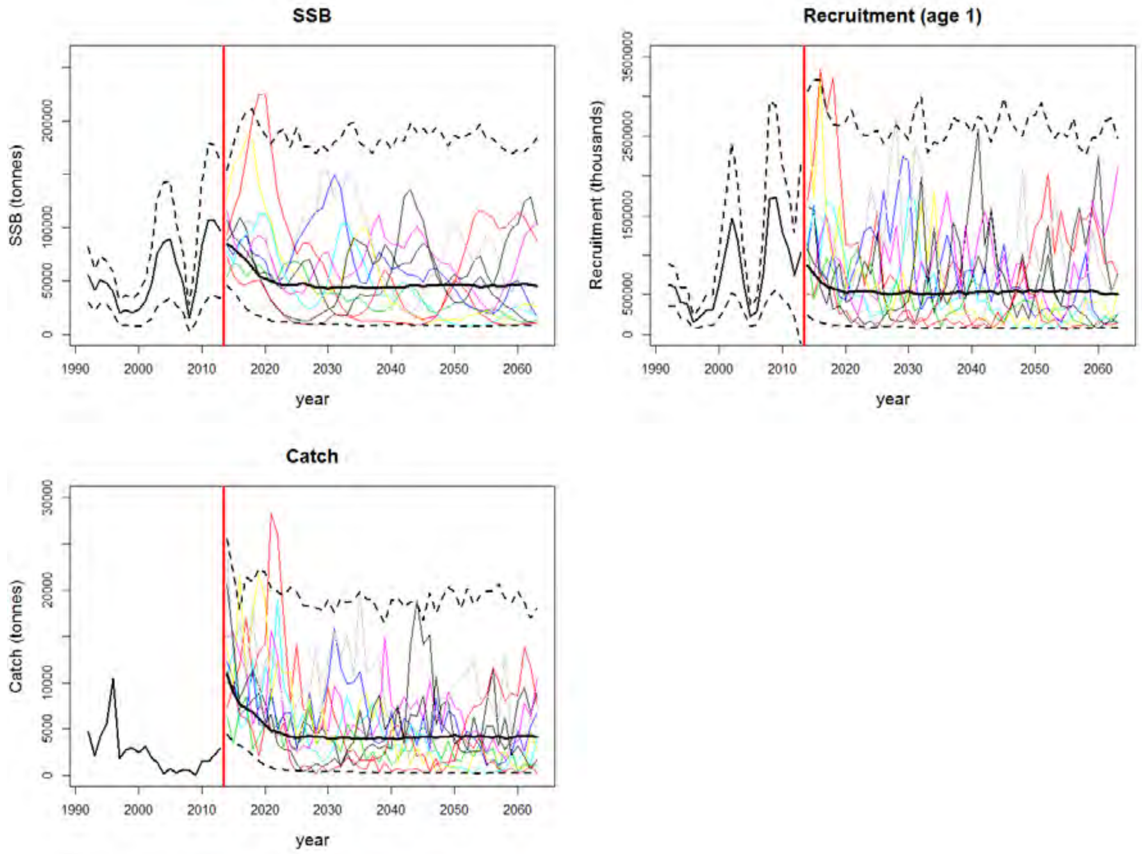

Figure 25b F=0.25 is taken from Figure 25a (but showing 95% confidence bounds instead of 90%) and the historic estimates (SSB, recruitment) with uncertainty (±2 standard deviations) or historic observations (catch) plotted for context. The vertical red line separates the baseline assessment estimates from the projections.

Table 10 Results from implementing F-based HCRs in terms of mean SSB, Yield and associated Risk; 90% confidence intervals (lower and upper CIs) are also shown.

F	SSB	lower CL	upper CL	Yield	lower CL	upper CL	Risk
0.00	60567	22407	147673	0	0	0	4.1
0.05	58065	21229	141779	1253	422	3251	4.8
0.10	55994	20232	137204	2332	772	6013	5.6
0.15	54118	19315	133205	3272	1054	8423	6.4
0.20	52349	18402	129023	4086	1296	10521	7.0
0.25	50964	17518	125190	4811	1492	12439	7.6
0.30	49564	16763	121700	5479	1638	14120	8.2
0.35	48340	16077	118502	6048	1755	15611	9.0
0.40	47162	15559	115579	6574	1830	16917	9.7
0.45	45989	14907	112975	7014	1909	18092	10.5
0.50	45024	14267	110725	7428	1988	19155	11.0
0.55	44200	13696	108561	7786	2055	20056	11.6
0.60	43297	13136	106373	8124	2111	20991	12.2
0.65	42580	12626	104659	8416	2150	21934	12.7
0.70	42019	12168	103412	8662	2184	22609	13.2
0.75	41581	11875	102168	8900	2215	23103	13.6
0.80	41194	11610	100905	9077	2205	23476	14.0
0.85	40852	11362	100100	9217	2200	23868	14.4
0.90	40547	11129	99521	9341	2197	24334	14.7
0.95	40282	10818	99068	9488	2203	24725	14.9
1.00	40003	10643	98657	9598	2211	24976	15.2

The results from implementing HCRs are illustrated in Figure 26. The increase in harvest rate results in a gradual reduction in SSB and increased associated risk of falling below Blim (=14 830 tonnes). As F increases, yields increase monotonically towards an asymptote just under 10 000 tonnes. However, annual yields would be less than 1 532 tonnes on average if keeping risk < 5% was a management objective.

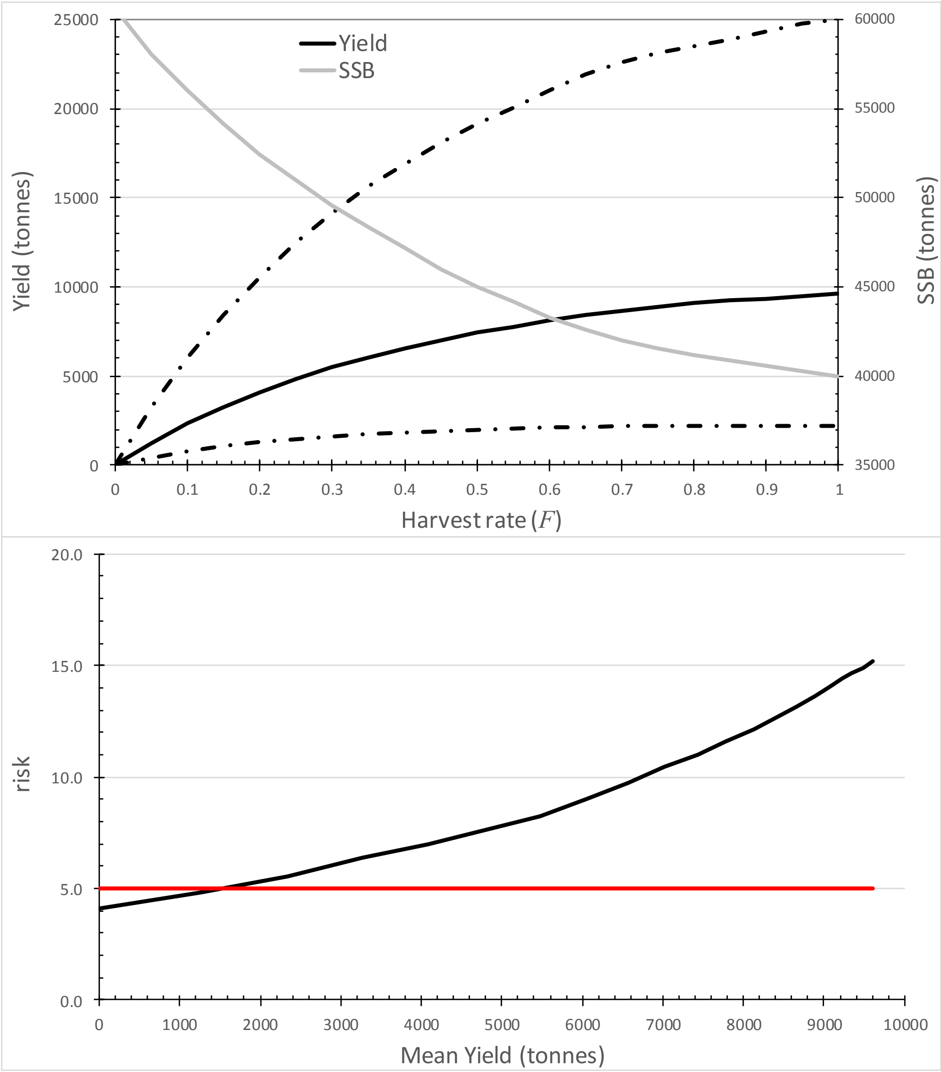

Figure 26 Results for the F-based HCR for a range of F values. Mean yield and SSB for increasing F values (upper plot); the dashed black lines represent 90% confidence intervals. Risk associated with the mean yield (lower plot); the red line indicates the 5% risk.

Discussion

Assessment model

An age-structure production model (ASPM, a particular formulation of a statistical catch-at-age model) is used to assess the San Francisco Bay herring stock. The model incorporates two indices of abundance (SSB and recruitment) and age-structured information from commercial and research catches, and includes a simple formulation of a stock–recruit curve as part of its estimation. The model provides a framework for integrating the spawning and catch at age information as suggested by a previous review of the San Francisco Bay herring assessment (Schweigert 2003).

Several considerations were taken into account when deriving the baseline model. The initial model did not impose any constraints on selectivity, which led to strong dome selection for both the fishery and research catches (stronger for the latter) because of the age-structure implied by these data, and therefore to a cryptic biomass, which was difficult to justify and potentially contributed to resilience to fishing that may not be realistic. This was addressed by introducing flat-topped selection for the commercial fishery, coupled with a plus-group mortality factor to deal with the model mis-specification for the plus-group when fitting to the commercial proportions-at-age data. A further feature that appeared to be important was the introduction of an oil-spill factor for 2007; this factor led to substantial improvements in model fit, despite there being no direct evidence for any detrimental effect of the oil spill on the herring population.

The baseline model fits the commercial and research catch at age averages well. Some patterns are noted in the residuals from the fit to data by year, but that is not a major concern. The fit to the SSB index and the recruitment are reasonable but the data are highly variable and the model cannot always fit large interannual variations. The very large 2005 SSB index data was followed by low SSB indices, although landings from 2004/05 on were relatively low. As the model cannot explain these data, it interprets the large 2005 SSB data point as noise. Retrospective analyses indicate reasonable behaviour, with retrospective fits lying well within the confidence bounds for the full model. All in all, we believe that the model is doing its best at reconciling the commercial and the scientific data available.

Natural mortality (M) has been estimated by the baseline model at 0.53. Comparison with estimates of natural mortality for British Columbia herring stocks (Schweigert and Tanasichuk 1999) indicate that this is likely to be a realistic value, although confidence intervals are relatively wide (0.24–0.98).

Several sensitivity tests were carried out, related to fishery selection, natural mortality, maturity, recruitment variability, the form of the stock–recruit relationship and the nature of the SSB index (absolute or relative). Alternative fishery selection (to deal with a mesh change in the early- to mid-2000s, and an even stronger flat-topped commercial selectivity) and natural mortality (increasing with age, after Tanusichuk 1999) did not lead to model improvements (and often to a deterioration in model diagnostics), and the increase in age 2 maturity served only to exacerbate the discrepancy between maturity and fishery selection (implying that even more mature fish escape the fishery prior to first spawning). The model was not able to estimate the steepness parameter of the more complex Beverton–Holt formulation; increasing the recruitment variability increased flexibility but also resulted in a slight deterioration in model fit. Finally, forcing the constant of proportionality parameter to be 1 (implying the SSB index is absolute) leads to a significant deterioration in model fit and a re-scaling of the population.

Despite no substantial improvements over the baseline model, the sensitivity tests did highlight other model settings that could be treated as alternative plausible model fits, which could form the basis of a set of alternative operating models for further MSE development. Settings resulting in diagnostics that indicated model mis-specification (e.g. misfits to commercial proportions-at-age in models 3 and 13) should be omitted from this set.

There are some challenges with the models presented. They are subject to high levels of uncertainty (e.g. confidence bounds around SSB, harvest rate and recruitment estimates are high throughout). There is also confounding between dome-shaped commercial selection on the one hand, and flat-topped selection coupled with a high plus-group mortality factor on the other; the model is not able to distinguish between these two extremes on the basis of the data, and the only argument used in favour of the latter (for the baseline model) was the spectre of a cryptic biomass, but the former cannot be discounted. A further issue for the models presented is the maturity ogive relative to the commercial selectivity (Figure 24), the latter estimated on the basis of the age-structure information in the commercial catches; this comparison implies that a large proportion of fish escape the fishery prior to their first spawning, and this has implications for population dynamics evident in the stochastic projections presented, where the stock appears to be quite resilient to fishing (Figures 25a and 26).

Another consideration that may need further attention is the relative weighting that the different sources of information receive in the model fit. For the baseline model, the abundance indices (SSB and recruitment) have variability parameters that are at least 4.5 × larger than the proportions-at-age data (commercial and research; Table 4a), implying a much higher weight for the proportions-at-age data relative to the abundance indices. This implies that the indices of abundance have a much lower influence on the model fit compared to the proportions-at-age data. Francis (2011) advocates applying data weighting such that the model is able to fit abundance data well, and there may be a case for following this approach here. Nevertheless, when this issue arose during the Training Workshop (held as part of the development of this work), participants were comfortable with the age composition data receiving more weight relative to the abundance indices in the model fit.

Finally, the performance of the models and reliability of output presented rely on the quality and quantity of data and information provided. Model performance and outputs, and estimation of reference points, may be improved by extending it back in time to include earlier periods of (validated) data.

Stochastic projections and initial harvest control rules

Stochastic projections were used to explore the impact of different harvest rates on the population, and to estimate MSY reference points. A comparison of SSB and recruitment trajectories in future projections with model estimates of these quantities in the past show that they are reasonably consistent with one another (Figure 25b), indicating that the stochastic projections (and operating models used in MSE simulations) appropriately recreate past behaviour.

Stochastic projections showed resilience to fishing, demonstrated by the narrow range of risk relative to the wide range of harvest rates (top plots in Figure 23). This is primarily caused by the commercial selectivity estimated on the basis of the commercial proportions-at-age data, and the difference between this selection pattern and the maturity ogive, implying a large proportion of fish are able to reproduce prior to being vulnerable to fishing. This is also evident in the inability to estimate MSY reference points (upper plots in Figure 23, where the vertical red line indicating is at harvest rate F=1). This behaviour is not attributable to the use of the fixed hockey stick (with the breakpoint at the lowest SSB estimated) because a change in commercial selectivity to reflect full selection for all ages leads to a harvest rate F_{MSY} estimate of 0.3 (albeit with a high associated risk of 46%, indicating that 0.3 may be too high for this stock under full selection; lower plots of Figure 23). The current fishery is primarily conducted with gillnets, which target larger and older fish than round-haul nets, which are less selective (Dahlstrom 1977), so the estimated commercial selection pattern of the baseline model appears reasonable.

The resilience to fishing (narrow range of risk for a wide range of harvest rates), demonstrated by the baseline model with its commercial selection pattern, cannot be interpreted in isolation. Despite this resilience, the high model uncertainty implies that, even under zero fishing, the risk of falling below Blim is non-zero (risk=4.1%). It is up to managers to decide an appropriate level of risk for the stock; under the ICES system (ICES 2016a), 5% is used, so an appropriate harvest rate would be just above 0.05 under that system (results not shown in tabular form, but are associated with the upper plots in Figure 23).

These findings appear to contradict those from a previous study which used the Coleraine catch-at-age model to assess the stock (MacCall *et al*. 2003, Schweigert 2003). At the time the stock was estimated to be at around 20% of the unfished level and was near the lowest abundance observed since the early 1970s, and a harvest range between 10 and 15% was recommended for sustainable utilisation (MacCall *et al*. 2003). It is difficult to compare results from the models presented here with those from the Coleraine model applied earlier because details are lacking for the latter (e.g. model structure and assumptions and what data was actually used), but there are important differences to note. The models are based on different time periods of data with an overlap of around ten years between them, and the Coleraine model covered a period of long-term decline in stock abundance (Schweigert 2003), whereas the underlying data in the models developed here show more contrast (the stock recovers after a steady decline). Furthermore, there was an acknowledgment in the

2003 peer-review report that the general-purpose Coleraine model was not specifically designed for assessing San Francisco Bay herring and that a future specialised model "may produce results that differ in unanticipated respects" (MacCall *et al*. 2003). Nevertheless, there appear to be some consistencies in the approaches, such as harvest rates above 20% in the 1990s (Figure 12) and that fishery exploitation allows "a proportion of the age 3 and most of the age 2 fish an opportunity to spawn" (MacCall *et al*. 2003; Figure 24).

Reference points used in conjunction with estimates of current biomass and harvest rate would allow determination of the status of the stock in relation to these reference points. Based on data up to the 2013/14 season, the stock was being fished sustainably because the spawning stock biomass was well above precautionary limits (SSB in 2014 = 85 477 tonnes, substantially above Bpa = 20 762 tonnes) and was fished at a harvest rate below 0.05 (harvest rate in 2013 = 0.037), the level that falls within the ICES 5% risk criterion.

An operating model to test harvest control rules for management was developed within an MSE framework, conditioned on the baseline assessment. Harvest rules considered were based on a constant harvest rate, which would be reduced if the stock was below a biomass precautionary reference point (Bpa = 20 762 tonnes was used). The reduction in harvest rate, F, provides the opportunity for recovery when the stock is low. There is, however, a high associated risk, even at low-F HCRs, because the uncertainty in the basic population parameters is large. Fishing mortality just above 0.05 results in 5% risk (Table 10). Estimates of risk rise slowly thereafter, so F may be increased substantially with little increase in associated risk (F = 0.2 results in 7% risk; Table 10).

The MSE framework and HCRs presented are preliminary and have not been fully developed here. Ideally, a suite of operating models covering the main sources of uncertainty (e.g. those considered in the sensitivity tests) would form the basis of the MSEs, and the robustness of HCRs tested against these operating models. Such operating models could also comprise "catastrophic events" or changes in productivity (due to environmental changes, for example) that have not been observed, but are nevertheless possible (Punt *et al.* 2014, De Oliveira *et al*. 2008, Kell *et al*. 2006). Furthermore, a much wider range of performance statistics than developed here could be considered, and fully developed MSEs should incorporate stakeholder input and interactions, as well as an in-depth consideration of the objectives for management of the fishery (Punt *et al*. 2016). Such work is beyond the scope of this study. The intention was to develop stochastic projections in such a manner that they could be readily converted into an MSE framework for testing alternative HCRs. The work presented here is a step towards a fully developed MSE framework.

As an example of the possible use of HCRs tested within an MSE framework, the results presented in this report could be used as follows for management:

1. Stakeholders decide on an appropriate harvest control rule (HCR), following consideration of the results from the simulations presented, and appraisal of acceptable levels of risk.
2. Once commercial catch and survey data are available following fishing season *y* (1st November in year *y* to 31st October in year *y*+1), add these data to current time-series of data and update the assessment.

3. Use the assessment estimates of $\hat{B}_y^{exp}$ and $\hat{B}_y^{sp}$ in the HCR (see equation 1 above) to calculate the TAC for the next season, *y*+1.

[Note that in this scheme, the simulations assume that the data from one season will be immediately available following that season to be used to run the assessment and to advise a TAC for the very next season.]

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References

Baxter, R., Hieb, K., DeLeón, S., Fleming, K. and J. Orsi. 1999. Report on the 1980–1995 fish, shrimp, and crab sampling in the San Francisco Bay estuary, California. Edited by J. Orsi. The Interagency Ecological Program for the Sacramento-San Joaquin Estuary. Technical Report 63, California Department of Fish and Game: [viii] + 503pp.

Butterworth, D. S. and R. A. Rademeyer. 2008. Statistical catch-at-age analysis vs. ADAPT-VPA: the case of Gulf of Maine cod. ICES Journal of Marine Science, 65: 1717–1732.

Dahlstrom, W. A. 1977. Selectivity of gillnets in the California Pacific herring roe fishery. Marine Resources, Administrative Report No 77–5: 9pp.

De Oliveira, J. A. A. 2003. The development and implementation of a joint management procedure for the South African pilchard and anchovy resources. Ph.D. thesis, University of Cape Town, Cape Town: [iv] + 319pp.

De Oliveira, J. A. A., Kell, L. T., Punt, A. E., Roel, B. A. and D. S. Butterworth. 2008. Managing without best predictions: the Management Strategy Evaluation framework. In Advances in Fisheries Science. 50 years on from Beverton and Holt, pp. 104–134. A.I.L. Payne, A.J.R. Cotter and T. Potter (Eds). Blackwell Publishing, Oxford. xxi + 546 pp.

Ernst, B. 2002. An investigation on length-based models used in quantitative population modeling. Ph.D. thesis, University of Washington, Seattle: 150pp.

Fournier, D. A., Sibert, J. R., Majkowski, J. and J. Hampton. 1990. MULTIFAN a likelihood-based method for estimating growth parameters and age composition from multiple length frequency data sets illustrated using data for southern bluefin tuna (Thunnus maccoyii). Can. J. Fish. Aquat. Sci. 47: 301-317.

Fournier, D. A., Skaug, H. J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M. N., Nielsen, A. and J. Sibert. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods and Software, 27:2, 233-249.

Francis, R. I. C. C. 2011. Data weighting in statistical Fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124–1138.
Hay, D. E. and P. B. McCarter. 1999. Age of sexual maturation and recruitment in Pacific herring. Canadian Stock Assessment Secretariat, Research Document 99/175: 42pp.
Hilborn, R. 1990. Estimating the parameters of full age-structured models from catch and abundance data. International North Pacific Fisheries Commission Bulletin, 50: 207–213.
Hilborn, R., Maunder, M.[N.], Parma, A.[M.], Ernst, B., Payne, J. and P.[J.] Starr. 2003. Coleraine. A generalized age-structured stock assessment model. User's Manual Version 2.0 (Revised May 2003): 58pp.
ICES 2003 Report of the study group on precautionary reference points for advice on fishery management. 24-26 February 2003, ICES HQ. ICES CM 2003/ACFM:15: [iv] + 81pp.
ICES 2013a. Report of the workshop on guidelines for management strategy evaluations (WKGMSE). 21-23 January 2013, ICES HA, Copenhagen, Denmark. ICES CM 2013/ACOM:39: [iii] + 122pp.
ICES 2013b. Report of the herring assessment working group for the area south of 62ºN (HAWG). 12-21 March 2013, ICES HQ, Copenhagen. ICES CM 2013/ACOM:06: [x] + 1270pp.
ICES 2016a. General context of ICES Advice. ICES advice basis, February 2016. [Accessed online, 19/12/2016: http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/2016/Introduction_to_advice_2016.pdf.]
ICES 2016b. ICES fisheries management reference points for category 1 stocks. ICES Advice Technical Guidelines.
Kell, L. T., De Oliveira, J. A. A., Punt, A. E., McAllister, M. K. and S. Kuikka. 2006. Operational Management Procedures: an introduction to the use of evaluation frameworks. In: The Knowledge Base for Fisheries Management. L. Motos and D.C. Wilson (Eds). Developments in Aquaculture and Fisheries Science, 36. Elsevier, Amsterdam: 379-407.
MacCall, A., Maunder, M. and J. Schweigert. 2003. Peer review of the California Department of Fish and Game's commercial Pacific herring fishery management and use of the Coleraine fishery model. Unpublished: 3pp.
McAllister, M. K. and J. N. Ianelli. 1997. Bayesian stock assessment using catch-age data and the sampling – importance resampling algorithm. Can. J. Fish. Aquat. Sci. 54: 284-300.
Mesnil, B. and M-J. Rochet. 2010. A continuous hockey stick stock–recruit model for estimating MSY reference points. ICES Journal of Marine Science, 67: 1780–1784.
Methot, R. D. 1989. Synthetic estimates of historical abundance and mortality for northern anchovy. Am. Fish. Soc. Symp. 6: 66-82.
Pope, J. G. 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. International Commission for the Northwest Atlantic Fisheries, Research Bulletin, 9: 65–74.
Punt, A. E. 1997. The performance of VPA-based management. Fisheries Research 29: 217-243.
Punt, A. E. and R. Hilborn. 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. Reviews in Fish Biology and Fisheries 7: 35-63.
Punt, A. E. and R. B. Kennedy. 1997. Population modelling of Tasmanian rock lobster, Jasus edwardsii, resources. Mar. Freshwater Res. 48: 967-980.
Punt, A. E., A'mar, T., Bond, N. A., Butterworth, D. S., de Moor, C. L., De Oliveira, J. A. A., Haltuch, M. A., Hollowed, A. B. and C. Szuwalski. 2014. Fisheries management under

climate and environmental uncertainty: control rules and performance simulation. ICES Journal of Marine Science, 71: 2208–2220.

Punt, A. E., Butterworth, D. S., de Moor, C. L., De Oliveira, J. A. A. and M. Haddon. 2016. Management strategy evaluation: best practices. Fish and Fisheries, 17(2): 303-334.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Schaefer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Inter-American Tropical Tuna Commission, Bulletin, 2: 247–285.

Schweigert, J. 2003. Review of the assessment framework for the San Francisco Bay herring fishery. Unpublished: 8pp.

Schweigert, J. and R. Tanasichuk. 1999. An evaluation of the natural mortality rate used in the assessment of British Columbia herring stocks. Canadian Stock Assessment Secretariat. Research Document 99/22: 23pp.

Shepherd, J. G. 1982. A versatile new stock-recruitment relationship for fisheries, and the construction of sustainable yield curves. J. Cons. Int. Explor. Mer. 40(1): 67-75.

Smith, A. D. M and A. E. Punt. 1998. Stock assessment of gemfish (Rexea solandri) in eastern Australia using maximum likelihood and Bayesian methods. In Fishery Stock Assessment Models. F. Funk, T.J. Quinn II, J. Heifetz, J.N. Ianelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan, and C.I. Zhang (Eds). Alaska Sea Grant College Program Report No. AK-SG-98-01, University of Alaska Fairbanks: 245-286.

Spratt, J. D. 1976. The Pacific herring resource of Tomales and San Francisco Bays: its size and structure. Marine Resources Technical Report No 33, California Department of Fish and Game: 44pp.

Tanasichuk, R. W. 1999. Natural mortality rates of adult Pacific Herring (Clupea pallasi) from southern British Columbia. Canadian Stock Assessment Secretariat Research Document 99/168: 34pp.

Watters, D. L. and K. T. Oda. 1997. Pacific herring, *Clupea pallasi*, spawning population assessment for San Francisco Bay, 1992-93. Marine Resources Division Administrative Report 97-3: 28pp.

Appendix 1
Data used in the assessment

This Appendix lists the data that were actually used in the assessment. Note that throughout, data in year *y* refer to the season covering the 1st November in year *y* to the 31st October in year *y*+1.

Table A1.1: Commercial catch (metric tons). The cell shaded grey indicates a zero value (but is replaced by a small number, 0.001, for computational reasons).

	Landings (tonnes)
1992	4670
1993	2085
1994	4149
1995	5501
1996	10465
1997	1783
1998	2734
1999	2955
2000	2401
2001	3071
2002	1902
2003	1396
2004	131
2005	674
2006	265
2007	623
2008	460
2009	0.001
2010	1566
2011	1482
2012	2115
2013	2901

Table A1.2: Maturity (based on Hay and McCarter 1999) and natural mortality (M) taken from North Sea herring estimates for 2012 (ICES 2013). Note that the M values shown below were used in the initial stages of the modelling but were finally replaced by values estimated in this assessment.

	Maturity	Natural mortality
1	0	0.66
2	0.36	0.38
3	0.94	0.35
4	1	0.34
5	1	0.33
6	1	0.32

Table A1.3: Commercial catch-at-age (thousands). Cells shaded grey are either zero (and replaced by a small number, 0.001, for computational reasons) or missing (indicated by "-1").

	1	2	3	4	5	6+
1992	141	1864	8751	15791	15701	3347
1993	38	445	4072	9423	7594	2546
1994	0.001	843	9783	11058	11233	4958
1995	0.001	4859	13143	21837	10168	3176
1996	0.001	9621	18866	32986	25037	10067
1997	0.001	2797	12137	6751	2414	625
1998	0.001	112	2990	10351	7092	3479
1999	0.001	1018	7307	9216	8874	2015
2000	240	785	11655	7327	2737	269
2001	0.001	2282	10287	12794	2131	1803
2002	0.001	2298	9397	6849	1283	0.001
2003	0.001	578	5591	5117	2262	340
2004	0.001	6	196	679	410	44
2005	0.001	0.001	464	4055	2262	211
2006	0.001	0.001	73	1200	1509	135
2007	0.001	0.001	76	2015	3912	503
2008	0.001	86	373	939	3347	401
2009	-1	-1	-1	-1	-1	-1
2010	0.001	2168	11898	4022	152	0.001
2011	0.001	476	7625	7091	1190	0.001
2012	0.001	258	4539	13249	4733	348
2013	0.001	106	3909	12239	12680	1633

Table A1.4: Commercial catch mean weight-at-age (kg). Cells shaded grey are assumed values (the 1998 value for age 1, and the average for a given age for ages 2-6). Mean weight-at-age in the stock is assumed equal to the mean weight-at-age in the catch.

	1	2	3	4	5	6+
1992	0.029	0.06	0.091	0.102	0.111	0.12
1993	0.029	0.049	0.065	0.081	0.098	0.113
1994	0.057	0.057	0.082	0.109	0.124	0.142
1995	0.052	0.062	0.093	0.107	0.119	0.134
1996	0.052	0.064	0.085	0.111	0.126	0.143
1997	0.052	0.055	0.066	0.077	0.099	0.112
1998	0.052	0.089	0.1	0.108	0.119	0.131
1999	0.052	0.085	0.096	0.104	0.11	0.115
2000	0.094	0.101	0.101	0.104	0.12	0.133
2001	0.052	0.09	0.102	0.107	0.117	0.106
2002	0.052	0.088	0.094	0.1	0.109	0.115
2003	0.052	0.086	0.096	0.104	0.106	0.105
2004	0.052	0.047	0.095	0.098	0.1	0.102
2005	0.052	0.073	0.089	0.094	0.101	0.104
2006	0.052	0.073	0.087	0.087	0.093	0.101
2007	0.052	0.073	0.099	0.087	0.099	0.109
2008	0.052	0.061	0.08	0.083	0.093	0.087
2009	0.052	0.073	0.089	0.097	0.106	0.115
2010	0.052	0.079	0.084	0.094	0.083	0.115
2011	0.052	0.082	0.086	0.094	0.1	0.115
2012	0.052	0.081	0.086	0.092	0.095	0.103
2013	0.052	0.080	0.086	0.091	0.100	0.105

Table A1.5: Research catch-at-age (thousands). Cells shaded grey are zero (and replaced by a small number, 0.001, for computational reasons). Note: age 1 was removed from the assessment input data because it is poorly correlated with both the corresponding YOY and the research data numbers at age in the subsequent year. [Note, these numbers have been raised to the spawning wave estimate, so do not reflect the absolute research catch sample numbers; they are, however, suitable to reflect the relative proportions amongst ages for any given year, as used in the assessment.]

	2	3	4	5	6+
1997	5734.8	18658.3	11837.5	5999	975.9
1998	37671	13561.1	37344.7	18203.6	4576.1
1999	38010.9	37426.3	16913.1	15783.9	1554.7
2000	38650.7	69479.5	26646.8	3515.9	1052.1
2001	89158.8	44123.1	20615.2	3030.5	0.6
2002	71821	41953	18431	3923.6	0.001
2003	304968.5	135147.5	29609.4	9347.9	3218.1
2004	285462.5	271791	206810.2	46558	0.001
2005	297677.1	879473.2	529758.4	191926.8	10355.9
2006	13185.9	39549.2	69769.9	23081.7	1364.4
2007	27831.9	22119	46434.3	22187.4	5186.2
2008	32809.6	16981.8	9227.5	6678.5	885.6
2009	498850.9	100920.7	20379.8	10221.7	5461.3
2010	187366	422290.2	70954.3	6017.2	0.001
2011	149060.8	347250.2	270119.9	18982.5	0.001
2012	174834.7	509636.3	380745.2	129589.6	787.4
2013	146198.9	287967.4	168350.2	70884.3	4430.3

Table A1.6: SSB and recruitment indices, the former (short tons) from egg deposition surveys, and the latter (number) from Young-of-the-Year surveys averaged over the months April-July. The cell shaded grey represents missing data (indicated by "-1"). Note, the recruitment index is for age 0 in April-July of year y, but the model assumes it represents an age 1 recruitment index for the $y/y+1$ season (modelled as year y in the assessment).

	SSB index	Recruitment index
1992	8169	74634
1993	21389	251464
1994	15481	-1
1995	50482	244298
1996	29361	65242
1997	3526	247072
1998	10550	64980
1999	9236	28683
2000	11331	442997
2001	11682	442921
2002	10996	884909
2003	32845	395108
2004	58789	68639
2005	144309	51757
2006	10601	48044
2007	10435	176938
2008	4322	923655
2009	38409	422271
2010	55356	536706
2011	59353	996900
2012	79509	175719
2013	60626	515471

Appendix 2
Description of the ASPM model

The ASPM model used follows the approach of Butterworth and Rademeyer (2008; Section B in their Supplementary Material). The following set of equations describe the basic population dynamics and contributions from the different sources of data to the (penalised) negative log-likelihood function. Quasi-Newton minimisation (using AD Model Builder; Fournier *et al.* 2012) is applied to estimate model parameters by minimising the total negative log-likelihood function.

Note that, throughout, y refers to the y /y+1 season (i.e. commencing 1st November in year y and ending 31st October in year y+1). Note also that in the description below, there are some components that are not used for San Francisco Bay herring, but because these options are available in the code (and may be useful in future), they are kept.

Basic Dynamics

Numbers-at-age

Numbers-at-age in the population are modelled by the following equations (which reflect Pope's form of the catch equation (Pope 1972), where catches are assumed to occur in a pulse in the middle of the fishing season):

$$N_{y+1,a} = \begin{cases} R_{y+1} & , a = a_{min} \\ N_{y,a-1}(1-F_{y,a-1})\, e^{-M_{y,a-1}} & , a_{min} < a < a_{pg} \\ N_{y,a_{pg}-1}(1-F_{y,a_{pg}-1})\, e^{-M_{y,a_{pg}-1}} + N_{y,a_{pg}}(1-F_{y,a_{pg}})\, e^{-M_{y,a_{pg}}} & , a = a_{pg} \end{cases} \qquad \text{A2.1}$$

for $y = y_{beg}, y_{beg}+1, \ldots, y_{end}$, where

$$F_{y,a} = \sum_{f} S^f_{y,a} F^f_y \qquad \text{A2.2}$$

and

$$F^f_y = \frac{C^f_y}{\sum_{a=0}^{a_{pg}} w_{a+\frac{1}{2}} S^f_{y,a} N_{y,a} e^{-M_{y,a}/2}} \qquad \text{A2.3}$$

where $N_{y,a}$ is the number of fish (thousands) aged a at the start of the $y/y+1$ season, R_y is the number of recruits (thousands) at the start of the $y/y+1$ season, $M_{y,a}$ is the natural mortality (per year) of fish age a during fishing season $y/y+1$, $F_{y,a}$ is the harvest rate of fish aged a during the $y/y+1$ season, $S^f_{y,a}$ is the selectivity of fish age a in fleet f during the $y/y+1$ season, F^f_y is the proportion of a fully selected age class that is fished by fleet f during the $y/y+1$ season, C^f_y is the catch (metric tonnes) by fleet f during the $y/y+1$ season, and $w_{a+\frac{1}{2}}$ is the mean weight (kg) of fish aged a caught mid-season. For San Francisco Bay herring, only a single commercial fleet is modelled, although at least two selectivity periods are considered (hence the y subscript in $S^f_{y,a}$); furthermore, $a_{min} = 1$

(age at recruitment), $a_{pg} \square 6$ (plus-group of age 6 and older), y_{beg}=1992 and y_{end}=2013. [Note, although in a different form and generalised for fleets, equations A2.1-3 are essentially the same as those given in Section B of the Supplementary Material of Butterworth and Rademeyer 2008).

Natural mortality

For the baseline model for San Francisco Bay herring, natural mortality is assumed to be year- and age-invariant (i.e. $M_{y,a} \square M$), apart from two cases. The first is related to the much lower numbers of plusgroup age 6 fish in both the commercial and survey observed proportions-at-age than would be expected under the assumption of age-invariant natural mortality (see main text). Therefore, a plusgroup mortality factor, $\square^{pgp}$, is introduced (so that $M_{y,6} \square \square^{pgp} M$ for all years except y=2007). The second is related to an oil spill in late 2007 which may have had a detrimental effect on herring mortality (see main text). To capture this effect, an oil spill factor, $\square^{oil}$, is introduced (so that $M_{2007,a} \square \square^{oil} M$ for ages 1-5, and $M_{2007,6} \square \square^{pgp} \square^{oil} M$).

Spawning biomass

Spawning biomass is based on mature fish, as follows:

$$B_y^{sp} \square \sum_{a \square a_{min}}^{a_{pg}} m_a w_a N_{y,a} \qquad \text{A2.4}$$

for $y = y_{beg}+1, y_{beg}+2, \ldots, y_{end}+1$, where B_y^{sp} is the spawning biomass (metric tonnes) at the start of the $y/y+1$ season, m_a is the proportion of fish mature at age a, and w_a is the mean weight (kg) of fish aged a at the start of the fishing season (other parameters and variables as before).

Recruitment

Shepherd stock–recruit function:
The number of recruits is related to the spawning stock, with a lag of a_{min} years (=1 year for San Francisco Bay herring) through a stock-recruit relationship. The Shepherd stock–recruit relationship (Shepherd 1982) is used for this purpose:

$$R_y \square \frac{\alpha B_{y \square a_{min}}^{sp}}{(\square \square (B_{y \square a_{min}}^{sp})^{\square})} e^{\square_y \square \square_R^2 / 2} \qquad \text{A2.5}$$

for $y = y_{beg}+1, y_{beg}+2, \ldots, y_{end}+1$ where the Shepherd stock–recruit parameters are re-parameterised in terms of K^{sp} (unfished or virgin spawning biomass, also referred to as carrying capacity) and h (steepness; defined as the proportion of R_{virgin} that would be produced by 20% of unfished spawning biomass) as follows:

$$\alpha \square \frac{R_{virgin} (K^{sp})^{\square \square 1} h (5 \square 0.2^{\square \square 1})}{5h \square 1} \qquad \text{A2.6}$$

and

$$\square \square \frac{(K^{sp})^{\square} (1 \square 0.2^{\square \square 1} h)}{5h \square 1} \qquad \text{A2.7}$$

where R_{virgin} is the recruitment level produced when the stock is at the unfished spawning biomass, K^{sp}, and α, β and γ are the parameters of the Shepherd stock–recruit function. Setting γ to 1 gives the Beverton–Holt function. The variables ς_y reflect annual fluctuations (estimated by the model) about the deterministic stock–recruit relationship, assumed to be normally distributed with mean zero and standard deviation σ_R.

Simple stock–recruit function based on virgin recruitment:
It is often difficult to estimate even two parameters of a stock–recruit relationship, let alone three. An alternative is to not impose a particular relationship between spawning biomass and recruitment, and instead simply estimate annual fluctuations about virgin recruitment, which reduces the number of parameters estimated by the model, as follows:

$$R_y = R_{virgin} e^{\varsigma_y - \sigma_R^2/2} \qquad \text{A2.8}$$

It should be noted that when conducting stochastic projections or evaluating harvest control rules in a Management Strategy Evaluation framework, it is not sensible to use A2.8 “as is”, particularly for levels of spawning biomass below the lowest level estimated, as it implies a resilient stock that continues to produce recruitment down to near-zero levels of spawning biomass – this approach would not be precautionary. For the stochastic projections and initial work on Management Strategy Evaluation presented, a hockey stock model is used instead, based on A2.8, but fixing the SSB breakpoint (i.e. where the curve starts to decline linearly to zero) at a suitable value (the lowest estimated SSB was used because of the lack of evidence for reduced recruitment at low stock sizes for this stock – see main text and Figure 3).

Calculation of virgin recruitment:
In all cases, virgin recruitment, R_{virgin}, is calculated as follows:

$$R_{virgin} = \frac{K^{sp}}{B^{spR}_{virgin}} \qquad \text{A2.9}$$

$$B^{spR}_{virgin} = m_{a_{\min}} w_{a_{\min}} + \sum_{a=a_{\min}+1}^{a_{pg}-1} m_a w_a e^{-\sum_{i=a_{\min}}^{a-1} M_{y,i}} + m_{a_{pg}} w_{a_{pg}} \frac{e^{-\sum_{a=a_{\min}}^{a_{pg}-1} M_{y,a}}}{1-e^{-M_{y,a_{pg}}}} \qquad \text{A2.10}$$

Equation A2.9 could be generalised as $R = B^{sp} / B^{spR}_{virgin}$, and this, in deterministic terms, represents the replacement line (i.e. it is the amount of recruitment needed at any level of spawning biomass to replace this spawning biomass).

Initial conditions

Given K^{sp}, the virgin (unfished) spawning biomass (i.e. the equilibrium B^{sp}, given constant recruitment and an absence of exploitation), and p_{virgin}, the proportion of the virgin population assumed as the starting conditions for the stock in year y_{beg}, the numbers-at-age and spawner biomass in year y_{beg} are:

$$B^{sp}_{y_{beg}} = p_{virgin} K^{sp} \qquad \text{A2.11}$$

$$N_{y_{beg},a} = \begin{cases} R_{y_{beg}} & , a = a_{\min} \\ p_{virgin} R_{virgin} e^{-\sum_{i=a_{\min}}^{a-1} M_{y,i}} & , a_{\min} < a < a_{pg} \\ \dfrac{p_{virgin} R_{virgin} e^{-\sum_{i=a_{\min}}^{a_{pg}-1} M_{y,i}}}{1 - e^{-M_{y,a_{pg}}}} & , a = a_{pg} \end{cases} \qquad \text{A2.12}$$

where $R_{y_{beg}}$ is calculated using equation A2.8, setting $y = y_{beg}$ (because a_{min}=1, A2.5 is not used; furthermore, the first residual, $\varsigma_{y_{beg}}$ in A2.5 and A2.8, is an estimable parameter).

Selectivity-at-age

Selectivity-at-age could be modelled either as a parametric function, or non-parametrically where selectivity at each age is estimated, apart from a pre-selected age (since selectivity is constrained to be no more than 1). The approach used for San Francisco Bay herring was to follow the non-parametric option, but the parametric formulation is kept for completeness.

Parametric [not used for San Francisco Bay herring]

The following is a logistic curve (defined by parameters β^j and δ^j) that has been modified up to age a^j_{bef} (by g^j_a) and from age a^j_{aft} onwards (by the exponential term $-\omega^j(a - a^j_{aft})$) to reflect, e.g. dome selection:

$$\tilde{S}^j_{y,a} = \begin{cases} 0 & , a = 0 \\ \dfrac{g^j_a}{1 + e^{-\beta^j(a-1)-\delta^j}} & , 1 \le a \le a^j_{aft} \\ \dfrac{g^j_a\, e^{-\omega^j(a - a^j_{aft})}}{1 + e^{-\beta^j(a-1)-\delta^j}} & , a > a^j_{aft} \end{cases} \qquad \text{A2.13}$$

where *j* refers to fleet *f* or survey *s*, and

$$g^j_a = \begin{cases} \theta^j & , a \le a^j_{bef} \\ 1 & , a > a^j_{bef} \end{cases} \qquad \text{A2.14}$$

Then, for any *a*

$$S^j_{y,a} = \tilde{S}^j_{y,a} / \max_a(\tilde{S}^j_{y,a}) \qquad \text{A2.15}$$

The y subscript in A2.15 reflects the possibility that a selectivity curve can be defined for one or more periods of the fishery (each with their own set of selectivity parameters). For simplicity, the y subscript is left off the other selectivity parameters.

Non-parametric [used for San Francisco Bay herring]

Given *j* (fleet *f* or survey *s*), then for *a = a** (age at which selectivity should reach a maximum) set $\tilde{S}^j_{y,a^*} = 1$ and treat the remaining $\tilde{S}^j_{y,a}$ as estimable (bounded to be ≥ 0), and calculate selectivity-at-age using equation A2.15. Note, for surveys ($j=s$), the selectivity is usually assumed constant over time, so the y subscript is dropped.

Exploitable biomass

Exploitable biomass models the component of biomass that is available to commercial fleet or survey, adjusted for the time during the fishing season the activity is assumed to occur.

Commercial fleets

The assumption for commercial fleets is for pulse fishing in the middle of the season, as follows:

$$B_y^f = \sum_{a=a_{\min}}^{a_{pg}} w_{a+\frac{1}{2}} S_{y,a}^f N_{y,a} e^{-M_{y,a}/2}(1-F_{y,a}/2) \qquad \text{A2.16}$$

Thus far, no commercial abundance indices are available for San Francisco Bay herring, so A2.16 is not used.

Surveys

A similar calculation is used for surveys, as follows:

$$B_y^s = \sum_{a=a_{\min}}^{a_{pg}} w_{a+t^s} S_a^s N_{y,a} e^{-t^s M_{y,a}}(1-t^s F_{y,a}) \qquad \text{A2.17}$$

where t^s is a pre-set parameter reflecting the timing (e.g. midpoint) of the survey relative to the start of the fishing season ($0 \le t^s \le 1$). However, the only indices available for San Francisco Bay herring is an SSB index and a recruitment index, and A2.17 is not quite appropriate for these. Instead, the following are used:

SSB index

$$B_y^s = B_y^{sp} \qquad \text{A2.17a}$$

where B_y^{sp} (metric tons) is from A2.4, and assumes the egg deposition survey measures spawning biomass at the start of the fishing season.

Recruitment index

$$B_y^s = N_{y,a_{\min}} \qquad \text{A2.17b}$$

where $N_{y,a_{\min}}$ (thousands of fish) is from A2.1 and assumes the Young-of-the-year surveys measure recruitment at the start of the fishing season that follows these surveys (i.e. the surveys held in the fishing season $y/y+1$ provide an age 1 recruitment index for the fishing season $y+1/y+2$). [Note: B_y^s in A2.17b is in numbers, while B_y^s in A2.17a is in biomass]

Proportions-at-age

Observed proportions-at-age, either in commercial catches or surveys, contain information about relative recruitment strength between cohorts, and can also be used to estimate the selectivity-at-age for corresponding fleets or surveys.

Note, for commercial fleets (*j*=*f*) and surveys (*j*=*s*), $a^j_{\min}$ and $a^j_{\max}$ reflect the minimum and maximum ages for which data are available, while a^j_{mngp} and a^j_{mxgp} reflect a contraction of the age-range to avoid zero values in the data (problematic when taking logs).

Commercial fleets

The model-predicted proportions-at-age for the commercial fleets use the estimated numbers of fish caught at age (assumed to be taken as a pulse in the middle of the fishing season), as follows:

$$\hat{p}^f_{y,a} = \begin{cases} \sum_{i=a^f_{\min}}^{a^f_{mngp}} S^f_{y,i} F^f_y N_{y,i} e^{-M_{y,i}/2} \Big/ \sum_{i=a^f_{\min}}^{a^f_{\max}} S^f_{y,i} F^f_y N_{y,i} e^{-M_{y,i}/2} & , a = a^f_{mngp} \\ S^f_{y,a} F^f_y N_{y,a} e^{-M_{y,a}/2} \Big/ \sum_{i=a^f_{\min}}^{a^f_{\max}} S^f_{y,i} F^f_y N_{y,i} e^{-M_{y,i}/2} & , a^f_{mngp} < a < a^f_{mxgp} \\ \sum_{i=a^f_{mxgp}}^{a^f_{\max}} S^f_{y,i} F^f_y N_{y,i} e^{-M_{y,i}/2} \Big/ \sum_{i=a^f_{\min}}^{a^f_{\max}} S^f_{y,i} F^f_y N_{y,i} e^{-M_{y,i}/2} & , a = a^f_{mxgp} \end{cases} \quad \text{A2.18}$$

The observed proportions-at-age for the commercial fleets are calculated in the same way, but the estimated numbers of fish caught are replaced by observed numbers of fish caught [in A2.18, $\hat{p}^f_{y,a}$ is replaced by $p^f_{y,a}$, and the term $S^f_{y,x} F^f_x N_{y,x} e^{-M_{y,x}/2}$ is replaced by $C^f_{y,x}$ (where x is either i or a, as appropriate). $C^f_{y,a}$ is the observed numbers of fish aged a caught during fishing season $y/y+1$]. For San Francisco Bay herring, $a^f_{mngp} = a^f_{\min} = 1$ and $a^f_{mxgp} = a^f_{\max} = 6$.

Surveys

The model-predicted proportions-at-age for the surveys use the estimated numbers of fish available to the survey at the time the survey is conducted (midpoint t^s, as defined above), as follows:

$$\hat{p}^s_{y,a} = \begin{cases} \sum_{i=a^s_{\min}}^{a^s_{mngp}} S^s_i N_{y,i} e^{-t^s M_{y,i}} (1 - t^s F_{y,i}) \Big/ \sum_{i=a^s_{\min}}^{a^s_{\max}} S^s_i N_{y,i} e^{-t^s M_{y,i}} (1 - t^s F_{y,i}) & , a = a^s_{mngp} \\ S^s_a N_{y,a} e^{-t^s M_{y,a}} (1 - t^s F_{y,a}) \Big/ \sum_{i=a^s_{\min}}^{a^s_{\max}} S^s_i N_{y,i} e^{-t^s M_{y,i}} (1 - t^s F_{y,i}) & , a^s_{mngp} < a < a^s_{mxgp} \\ \sum_{i=a^s_{mxgp}}^{a^s_{\max}} S^s_i N_{y,i} e^{-t^s M_{y,i}} (1 - t^s F_{y,i}) \Big/ \sum_{i=a^s_{\min}}^{a^s_{\max}} S^s_i N_{y,i} e^{-t^s M_{y,i}} (1 - t^s F_{y,i}) & , a = a^s_{mxgp} \end{cases} \quad \text{A2.19}$$

The observed proportions-at-age for the surveys are calculated in the same way, but the estimated numbers of fish available to the surveys are replaced by observed numbers of fish caught in the survey [in A2.19, $\hat{p}^s_{y,a}$ is replaced by $p^s_{y,a}$, and the term $S^s_x N_{y,x} e^{-t^s M_{y,x}} (1 - t^s F_{y,x})$ is replaced by $C^s_{y,x}$ (where x is either i or a, as appropriate). $C^s_{y,a}$ is the observed numbers of fish aged a caught during the survey in fishing season $y/y+1$]. For San Francisco Bay herring, $a^s_{mngp} = a^s_{\min} = 2$ and $a^s_{mxgp} = a^s_{\max} = 6$.

Constants of proportionality

Constants of proportionality relate observed indices to their model equivalents, and deal with any scaling issues (e.g. for the recruitment index, the model estimate, $B_y^s = N_{y,a_{\min}}$, is in thousands of fish, while the corresponding observation, U_y^s, is in numbers of fish). Closed-form solutions for these parameters are obtained by differentiating the total negative log-likelihood function with respect to the given parameter, setting the result equal to zero, and solving the equation for this parameter.

Commercial fleet CPUEs

$$q^f = \exp\left(\frac{\sum_{y \in Y_U^f} (\ln U_y^f - \ln B_y^f)}{\sum_{y \in Y_U^f} 1}\right) \qquad \text{A2.20}$$

where Y_U^f reflects the set of years for which commercial CPUE estimates, U_y^f, are available for feet f. Since commercial abundance indices are not currently available for San Francisco Bay herring, A2.20 is not used.

Survey CPUEs

$$q^s = \exp\left(\frac{\sum_{y \in Y_U^s} (\ln U_y^s - \ln B_y^s)/[(\sigma_{U,y}^s)^2 + (v_{adv}^s)^2]}{\sum_{y \in Y_U^s} 1/[(\sigma_{U,y}^s)^2 + (v_{adv}^s)^2]}\right) \qquad \text{A2.21}$$

where Y_U^s reflects the set of years for which the survey indices, U_y^s, are available for survey s. See below for further descriptions of the variability parameters $\sigma_{U,y}^s$ and v_{adv}^s.

Variability parameters

Variability parameters are associated with each data source, and provide relative weighting amongst the various data sources. These can be estimated either through a closed-form solution (as above for the constant of proportionality parameters), or where this is not possible, directly estimated.

Commercial fleet CPUEs

$$\sigma_U^f = \sqrt{\max\left(\frac{\sum_{y \in Y_U^f} [\ln U_y^f - \ln(q^f B_y^f)]^2}{\sum_{y \in Y_U^f} 1} - (v_{fix}^f)^2 \;;\; 0\right)} \qquad \text{A2.22}$$

where v_{fix}^f is a pre-specified constant allowing for a lower bound to be set on the total variance $(\sigma_U^f)^2 + (v_{fix}^f)^2$. Since commercial abundance indices are not currently available for San Francisco Bay herring, A2.22 is not used.

Survey CPUEs

The total variance is given by $(\sigma_{U,y}^s)^2 + (v_{adv}^s)^2$, which comprises a component $\sigma_{U,y}^s$ associated with "sampling" variability of individual survey estimates U_y^s which can be input (e.g. as sampling CVs from the survey), if available, while the "additional" variability parameters v_{adv}^s (variability not associated with sampling) are treated as estimable. Because sampling CVs are not available for San Francisco Bay herring, an arbitrary value, $\sigma_{U,y}^s = 0.05$, is used (for convenience only), and the v_{adv}^s estimated, so that $(\sigma_{U,y}^s)^2 + (v_{adv}^s)^2$ reflects the total variance for that data source.

Proportions-at-age

$$\sigma_p^j = \sqrt{\frac{\sum_{y\in Y_p^j}\sum_{a=a_{mngp}^j}^{a_{mxgp}^j} p_{y,a}^j(\ln p_{y,a}^j - \ln \hat{p}_{y,a}^j)^2}{\sum_{y\in Y_p^j}\sum_{a=a_{mngp}^j}^{a_{mxgp}^j} 1}} \qquad \text{A2.23}$$

where *j* refers to fleet *f* or survey *s*, and Y_p^j reflects the set of years for which $p_{y,a}^j$ estimates are available. Further details about the statistical distribution implied by this formulation is given below.

Likelihood function

The total negative log-likelihood function comprises several components related to the data sources that the model fits to, and a penalised likelihood term associated with recruitment deviations. These are all listed below. Estimation is by maximum likelihood (in practical terms, the total negative log-likelihood is minimised), where observations are assumed to have particular statistical distributions, reflected by the likelihood formulation of each component.

Commercial fleet CPUEs

Observations are assumed to be lognormally distributed, with total variance reflected by $(\sigma_U^f)^2 + (v_{fix}^f)^2$ as follows:

$$L_U^f = \tfrac{1}{2}\sum_{y\in Y_U^f}\left\{\left[L_{U,nres}^f(y)\right]^2 + \ln\left[2\pi\left((\sigma_U^f)^2 + (v_{fix}^f)^2\right)\right]\right\} \qquad \text{A2.24}$$

where

$$L_{U,nres}^f(y) = \frac{\ln U_y^f - \ln(q^f B_y^f)}{\sqrt{(\sigma_U^f)^2 + (v_{fix}^f)^2}} \qquad \text{A2.25}$$

Because commercial abundance indices are not currently available for San Francisco Bay herring, A2.24 and A2.25 are not used.

Survey Indices

Observations are assumed to be lognormally distributed, with total variance reflected by $(\sigma^s_{y,U})^2 + (v^s_{adv})^2$, with the first term representing sampling variance (input to the model, if available), and the second additional variance (not related to sampling), as follows:

$$L^s_U = \tfrac{1}{2}\sum_{y \in Y^s_U}\left\{\left(L^s_{U,nres}(y)\right)^2 + \ln\left[2\pi\left((\sigma^s_{y,U})^2 + (v^s_{adv})^2\right)\right]\right\} \quad \text{A2.26}$$

where

$$L^s_{U,nres}(y) = \frac{\ln U^s_y - \ln(q^s B^s_y)}{\sqrt{(\sigma^s_{y,U})^2 + (v^s_{adv})^2}} \quad \text{A2.27}$$

For San Francisco Bay herring, sampling variance $(\sigma^s_{y,U})^2$ is not available, so an arbitrary value, $\sigma^s_{y,U} = 0.05$, is used for convenience, and the additional variability parameter, v^s_{adv}, is estimated.

Proportions-at-age

Ernst (2002) identified three different approaches for treating age composition data in a likelihood function. All three approaches result in multinomial-type likelihoods. The first (the option usually used) assumes the age composition data have a multinomial distribution about their expected values (Methot 1989, Punt and Hilborn 1997). The second uses a "robustified" normal likelihood formulation (Fournier *et al*. 1990, Hilborn *et al.* 2003). These first two approaches require the specification of an effective sample size (i.e. number of independent sample units). This can prove difficult if age composition data are not based on simple random samples from the total catch, which is often the case (Punt and Kennedy 1997, McAllister and Ianelli 1997).

The third approach, adopted here and termed the adjusted lognormal distribution, avoids arbitrariness in the specification of the effective sample size by assuming a lognormal distribution for the age composition data, where the CV is taken to be inversely proportional to the square-root of the expected value (Punt and Kennedy 1997, Smith and Punt 1997, Ernst 2002). This form has its basis in the mean-variance relationship for multinomial sampling, and allows larger proportions to be given greater weight, so that undue importance is not given to observations based on only a few samples (Punt 1997, Punt and Kennedy 1997, De Oliveira 2003). Punt (pers. commn) has more recently suggested that a CV inversely proportional to the square-root of the observed rather than expected value should instead be considered for the lognormal formulation. This suggestion is based on the simulation work by Ernst (2002) that showed better performance (in terms of estimation bias) of the robustified normal likelihood when variance was based on observed rather than expected values. The adjusted lognormal formulation is as follows:

$$L^j_p = \tfrac{1}{2}\sum_{y \in Y^j_p}\sum_{a = a^j_{mngp}}^{a^j_{mxgp}}\left[\left(L^j_{p,nres}(y,a)\right)^2 + \ln\left(2\pi(\sigma^j_p)^2 / p^j_{y,a}\right)\right] \quad \text{A2.28}$$

where *j* refers to fleet *f* or survey *s*, and

$$L^j_{p,nres}(y,a) = \frac{\ln p^j_{y,a} - \ln \hat{p}^j_{y,a}}{\sqrt{(\sigma^j_p)^2 / p^j_{y,a}}} \qquad \text{A2.29}$$

Stock-recruit curve

Stock-recruitment residuals, ε_y, are assumed to be serially correlated and normally distributed with mean zero and variance σ_R^2, as follows:

$$L_R = \tfrac{1}{2}\sum_{y=y_{beg}}^{y_{end}} \left[\left(L_{R,nres}(y)\right)^2 + \ln\left(2\pi\sigma_R^2(1-\rho^2)\right) \right] \qquad \text{A2.30}$$

where (assuming $\varepsilon_{y_{beg}-1} = 0$)

$$L_{R,nres}(y) = \frac{\varepsilon_y - \rho\varepsilon_{y-1}}{\sqrt{\sigma_R^2\,(1-\rho^2)}} \qquad \text{A2.31}$$

For San Francisco Bay herring, ε_y are estimable parameters and the serial correlation, ρ, is set to zero during the model fit (simplifying A2.30 and A2.31), and only calculated after the model fit (often done for computational tractability), as follows:

$$\rho = \frac{\sum_{y=y_{beg}}^{y_{end}-1} \varepsilon_y \varepsilon_{y+1}}{\sqrt{\left(\sum_{y=y_{beg}}^{y_{end}-1} \varepsilon_y^2\right)\left(\sum_{y=y_{beg}}^{y_{end}-1} \varepsilon_{y+1}^2\right)}} \qquad \text{A2.32a}$$

For the purposes of stochastic projections and MSE (management strategy evaluation) simulations (performed after the model fit) recruitment serial correlation is accounted for as follows:

$$\varepsilon_y = \rho\varepsilon_{y-1} + \sqrt{1-\rho^2}\,\varepsilon^*_y \qquad , y = y_{end}+1, y_{end}+2, \ldots \qquad \text{A2.32b}$$

where y_{end} is the final year of the assessment (so $y_{end}+1$ is the first year of the projection period) $\varepsilon_{y_{end}} = \hat{\varepsilon}_{y_{end}}$ ($\hat{\varepsilon}_{y_{end}}$ being the final recruitment residual from the assessment), and ε^*_y being historic recruitment residuals sampled with replacement. ε_y then replaces ε_y in A2.5 or A2.8 for future years.

Total negative log-likelihood

Total negative log-likelihood, –lnL, is calculated as follows:

$$-\ln L = \sum_f L^f_U + \sum_s L^s_U + \sum_f L^f_p + \sum_s L^s_p + L_R \qquad \text{A2.33}$$

Note for San Francisco Bay herring L_U^f is not used (i.e. $L_U^f = 0$)

Input parameters

Input parameters, values which were derived by profiling over the negative log-likelihood surface (see main text), were

- Natural mortality, M
- Proportion of unfished spawning biomass, p_{virgin}
- Recruitment variability, σ_R

Estimable parameters

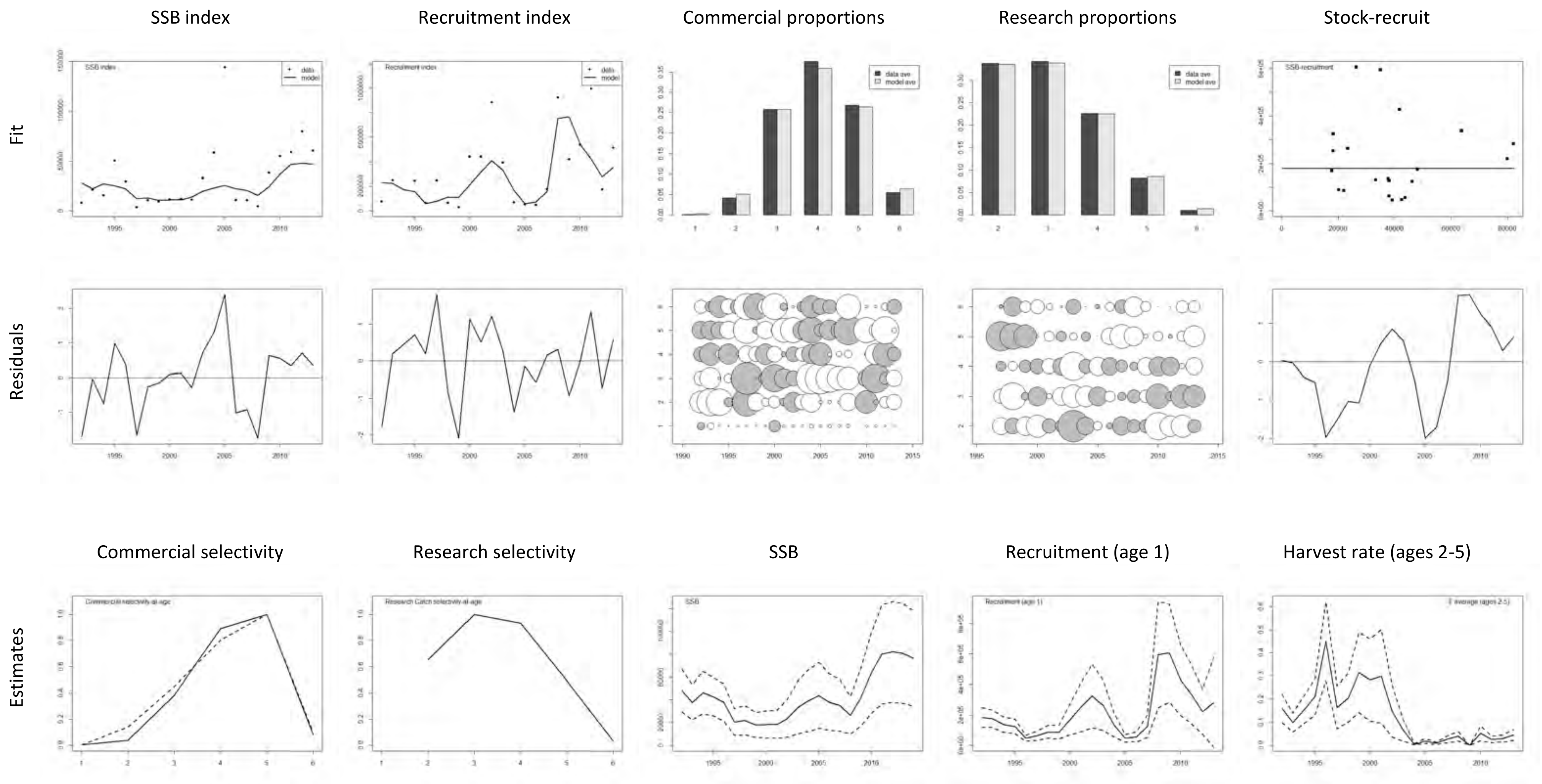
The estimable parameters (39 in total) of the baseline model are:

- Unfished spawning biomass, K^{sp} (although ln(K^{sp}) is actually estimated)
- Commercial selectivity, $S_{y,a}^f$, for two selectivity periods: y=1992-1997 and y=1998-2013; for a=1-4 (for the other ages, a*=5, and age 6 set equal to age 5, so $S_{y,6}^f = S_{y,5}^f = 1$)
- Survey selectivity, S_a^s, for a=2-5 (a*=6, so $S_6^s = 1$)
- Recruitment residuals, ε_y, for y=1992-2013
- Survey variability parameters, v_{adv}^s, one for the SSB index, $v_{adv}^{s,ssb}$, and one for the recruitment index, $v_{adv}^{s,rec}$
- The plus-group mortality factor, μ^{pgp}
- The 2007 oil spill mortality factor, μ^{oil}

Appendix 3

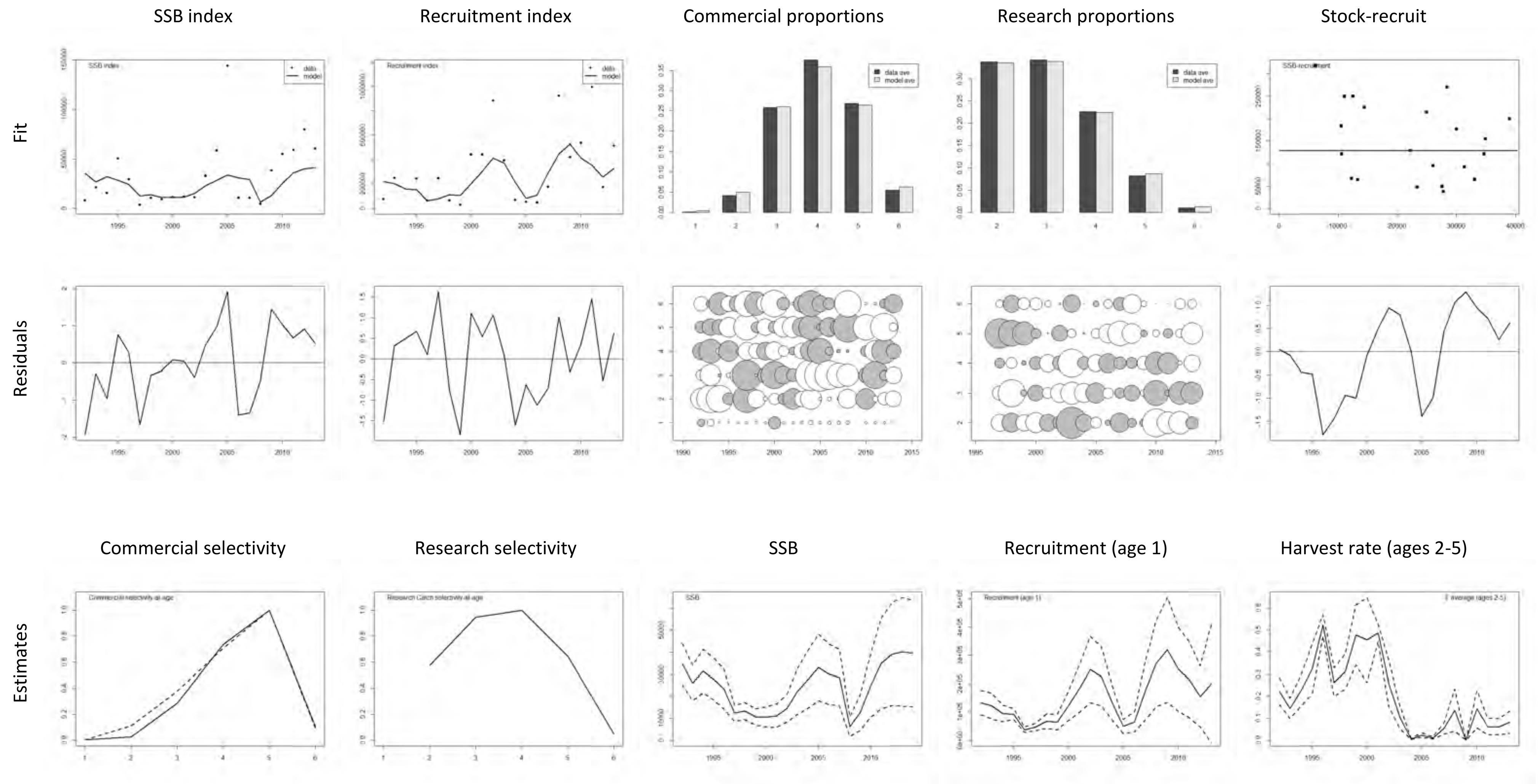
Initial model to baseline model

Model 1: Initial Model



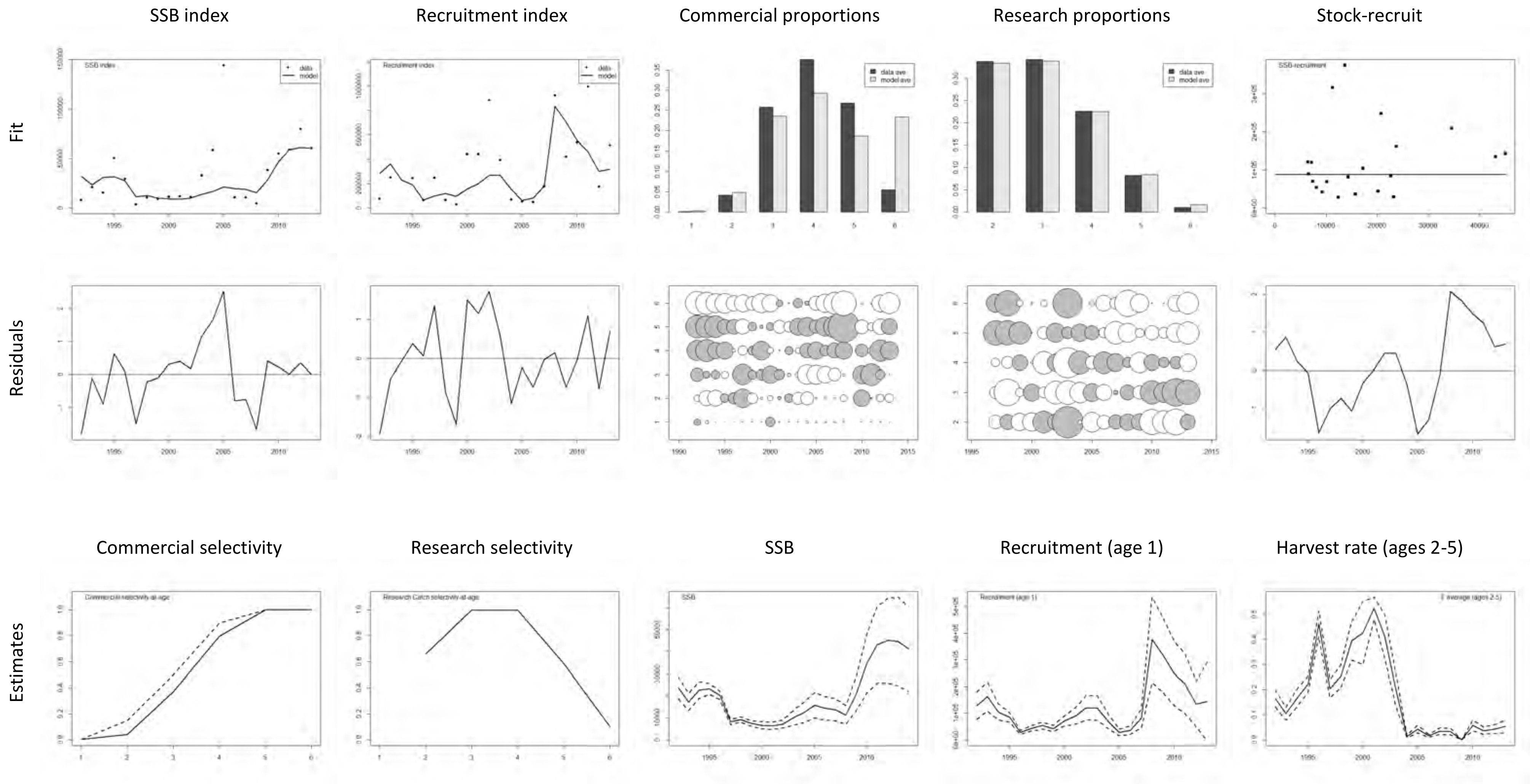
For more detailed explanation of the individual plots, please refer to the main text.

Model 2: Introduce, $\square^{oil}$, the 2007 M factor



For more detailed explanation of the individual plots, please refer to the main text.

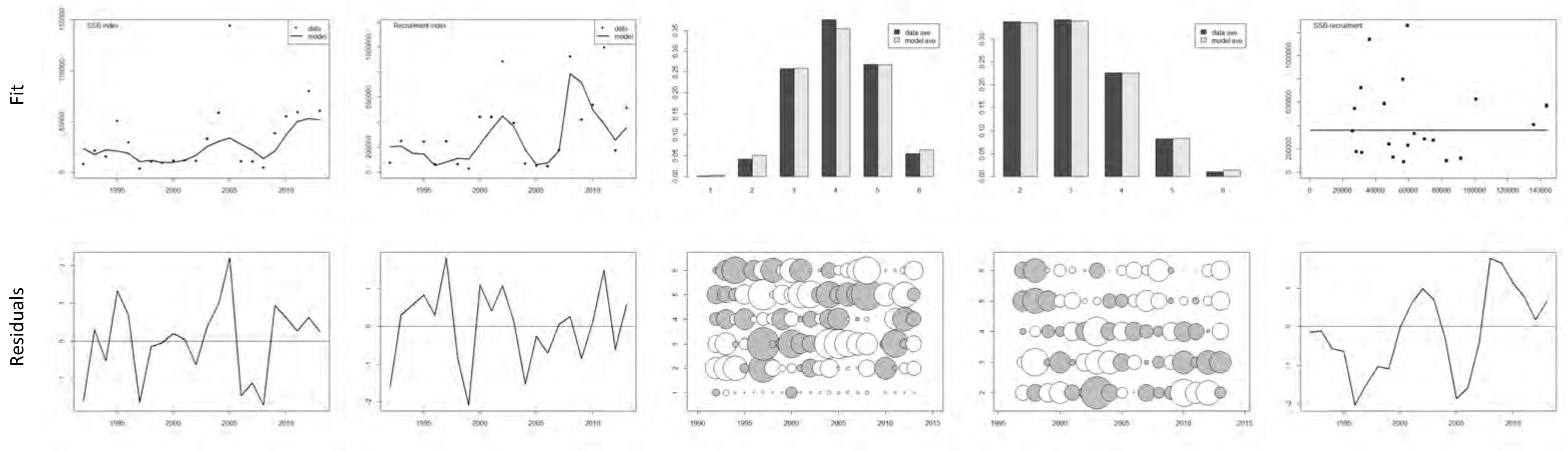
Model 3: Set □$^{f}_{y,6}$ □□$^{f}_{y,5}$ for commercial selectivity (to mimic flat-topped selection)



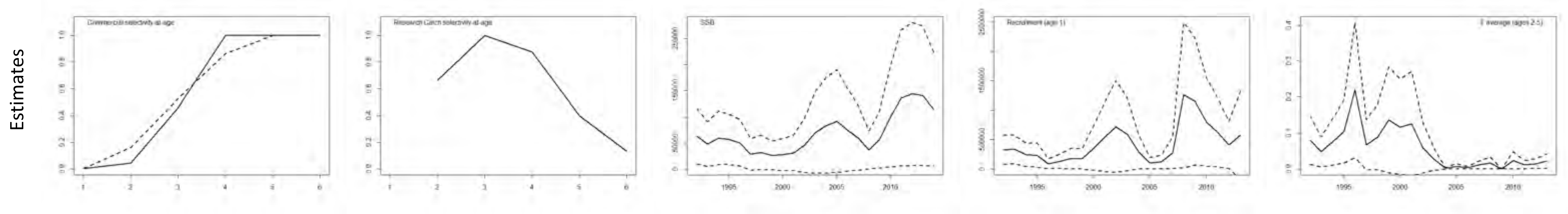
For more detailed explanation of the individual plots, please refer to the main text.

Model 4: As for model 3, but also introduced $\square^{pgp}$, the age 6 M factor

SSB index | Recruitment index | Commercial proportions | Research proportions | Stock-recruit



Commercial selectivity | Research selectivity | SSB | Recruitment (age 1) | Harvest rate (ages 2-5)



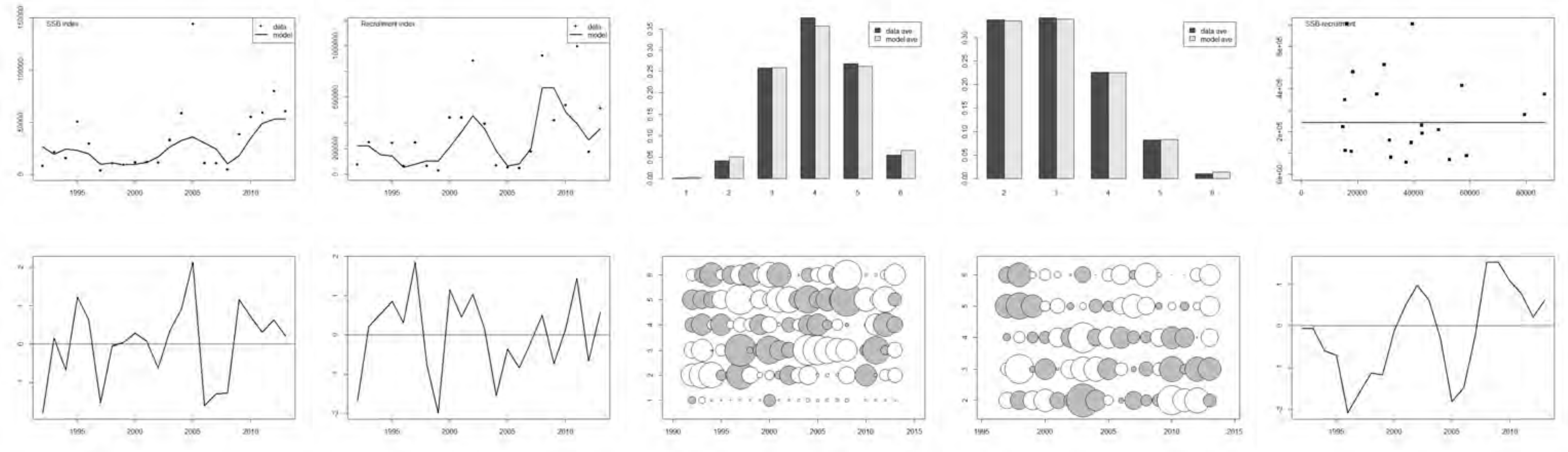
For more detailed explanation of the individual plots, please refer to the main text.

Model 5: As for model 4, but additionally introduce $\square^{oil}$ (so both $\square^{oil}$ and $\square^{pgp}$ are used)

SSB index | Recruitment index | Commercial proportions | Research proportions | Stock-recruit

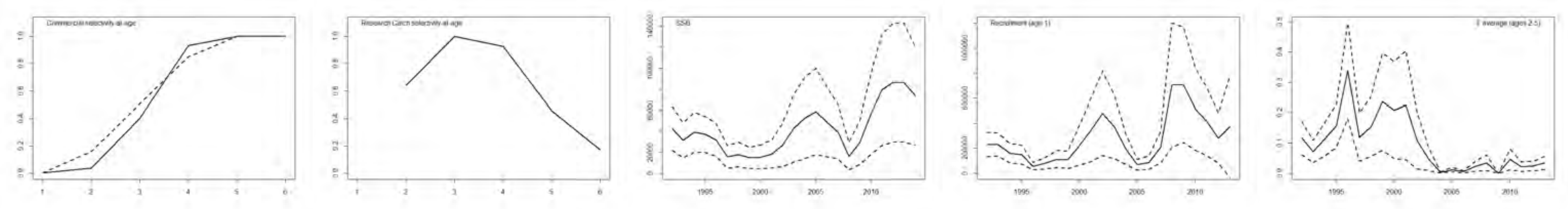
Fit

Residuals



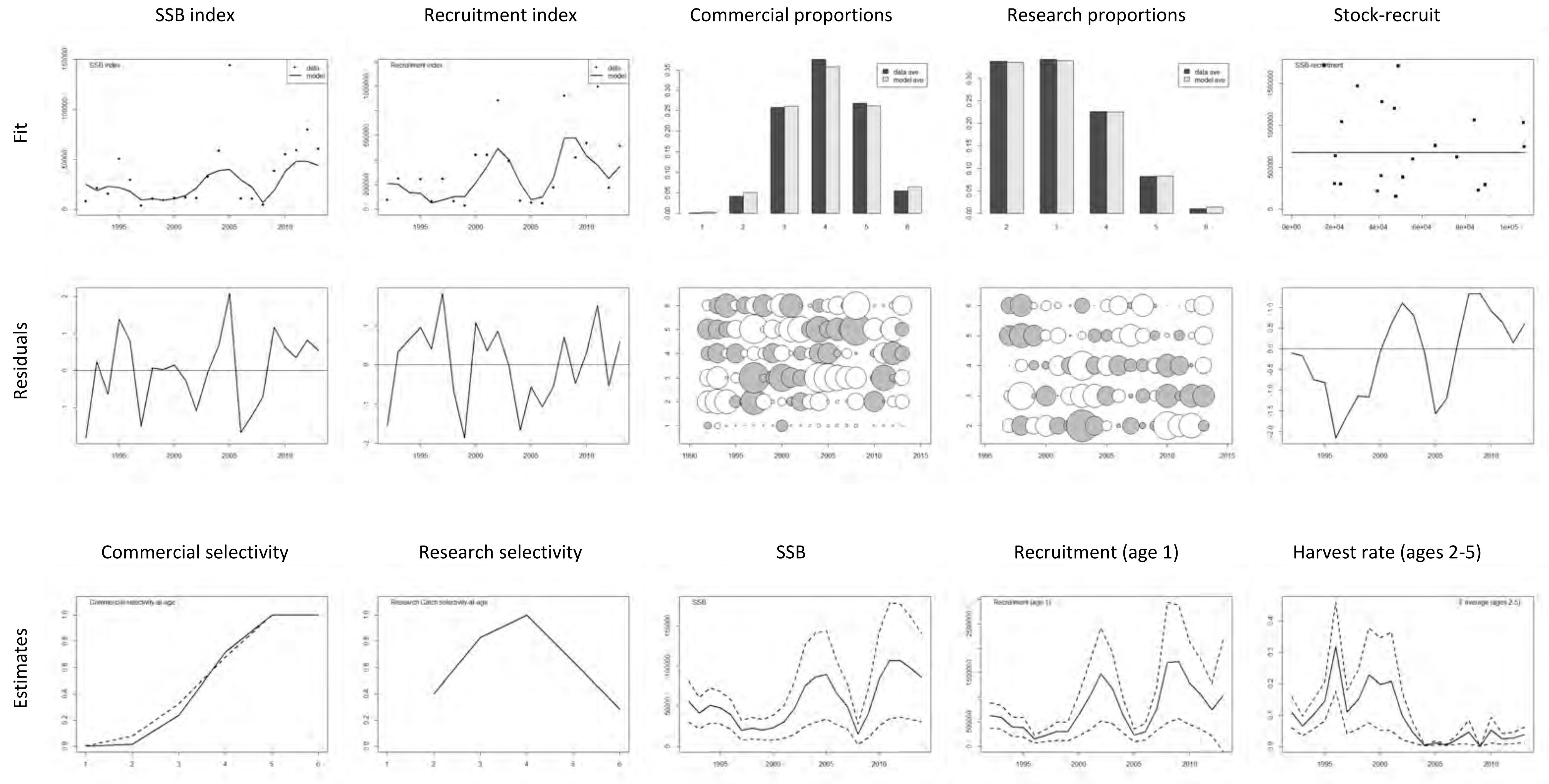
Commercial selectivity | Research selectivity | SSB | Recruitment (age 1) | Harvest rate (ages 2-5)

Estimates



For more detailed explanation of the individual plots, please refer to the main text.

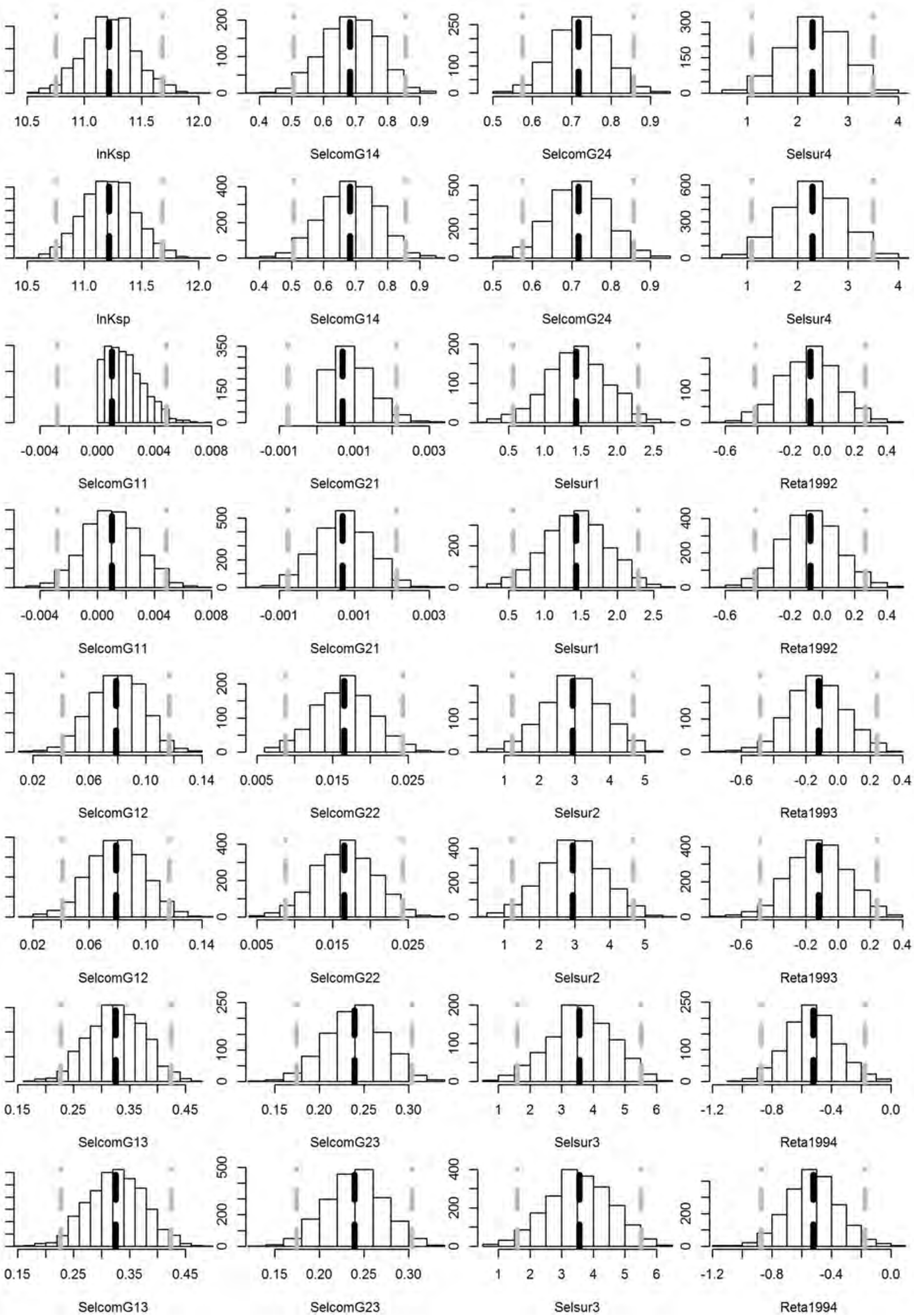
Model 6: As for model 5, but set M=0.53 (instead of 0.27), based on a likelihood profile

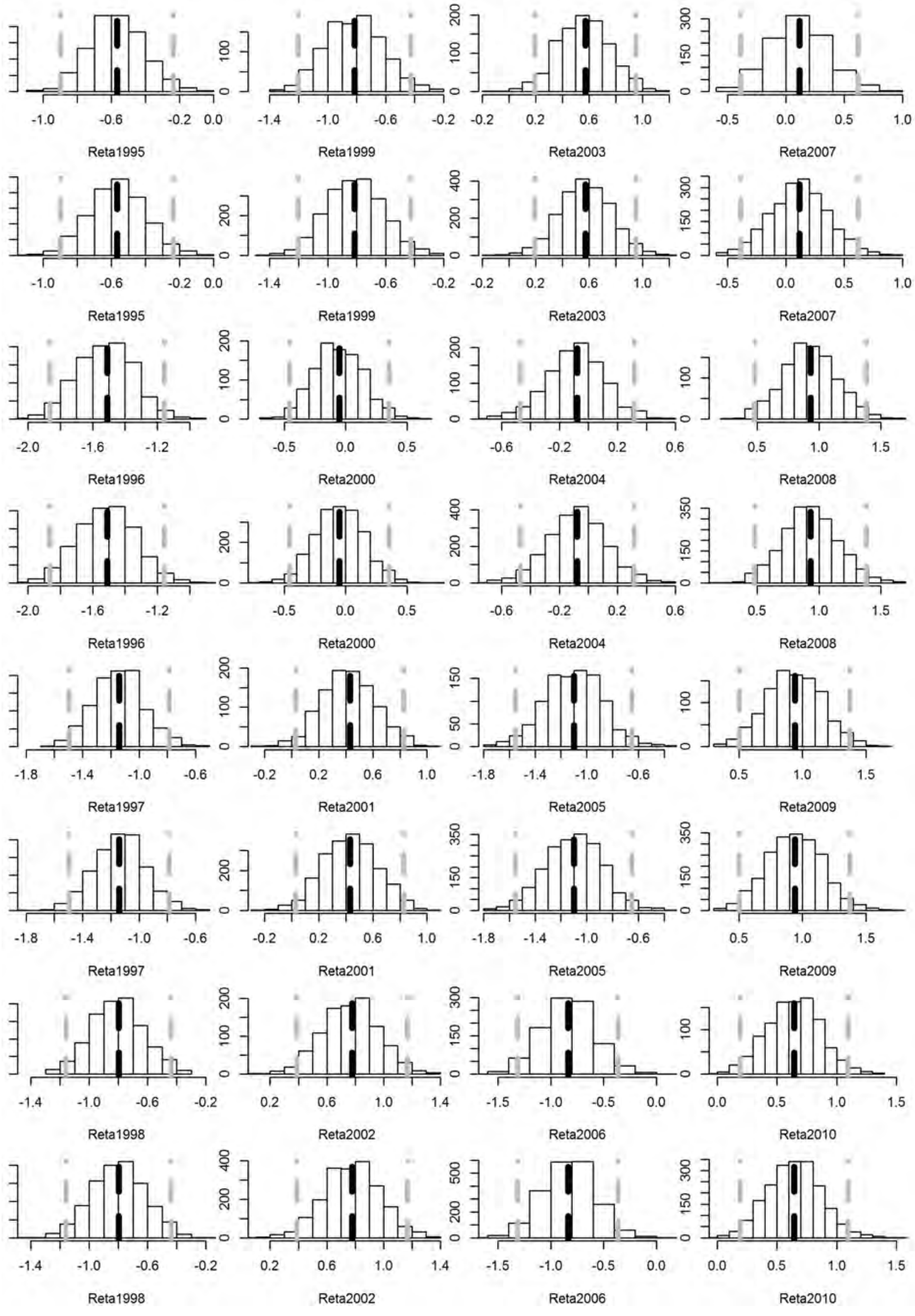


For more detailed explanation of the individual plots, please refer to the main text.

Appendix 4

Conditioning the operating model




Reta1995
Reta1999
Reta2003
Reta2007
Reta1995
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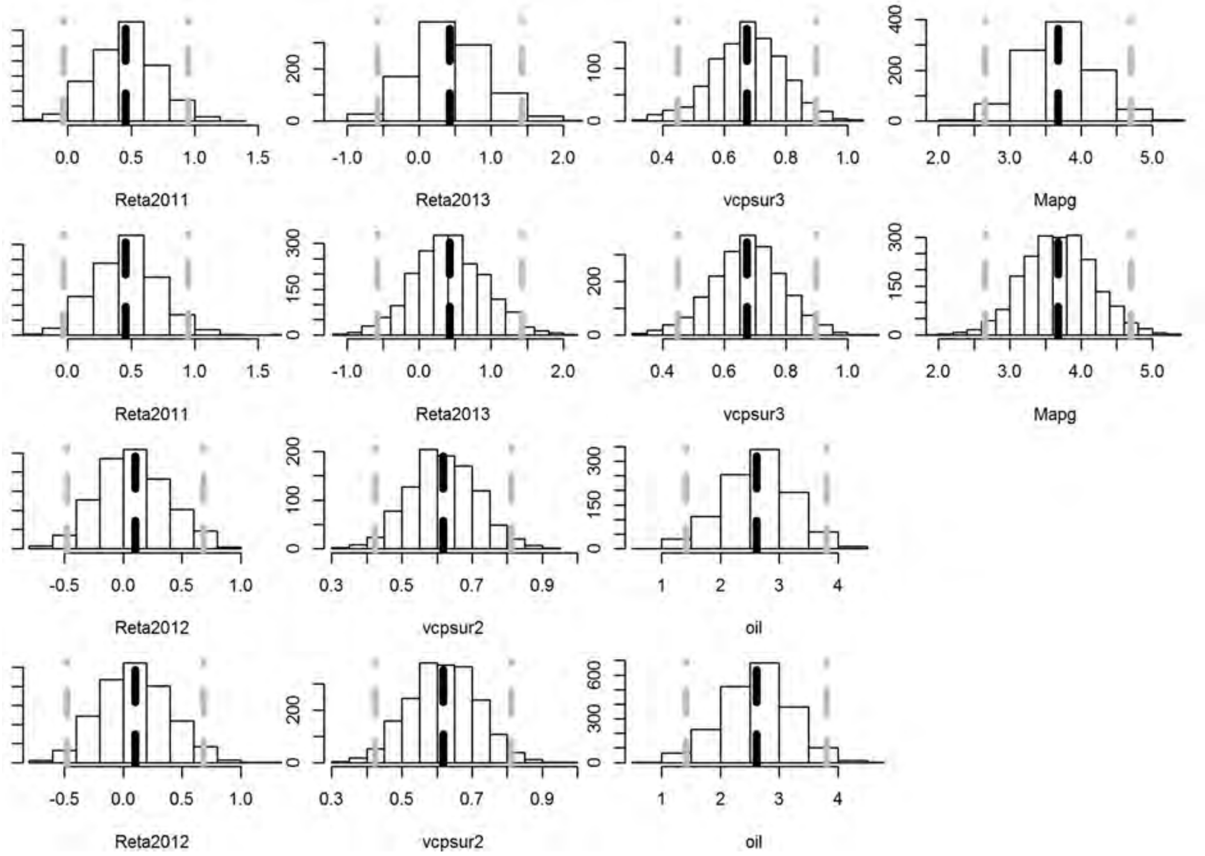

Figure A4.1 Parameter distributions after sampling from a multivariate normal distribution. For each parameter the upper plot shows the truncated distribution and the lower plot shows the full distribution. The black lines show estimates from the fit model and the grey lines show ±2 standard deviations. Where “lnKsp” is logarithm of virgin SSB, “Mapg” is the plus group mortality factor, “oil” is the 2007 oil spill factor, “Reta1992” to “Reta2013” are the residuals of the fit to the recruitment estimates, “Selcom” are the selectivity parameters at age for the commercial fishery, “Selsur” refer to selection at age for the research catch, and “vcpsur1” and “vcpsur2” correspond to the variability parameters for the SSB and recruitment indices.

Figure A4.2 Historic stock–recruit pairs for population i (red dots), with stock–recruit relationships fitted to these (solid black curves) and future recruitment (black dots) for 100 simulations. Serial correlation is included.

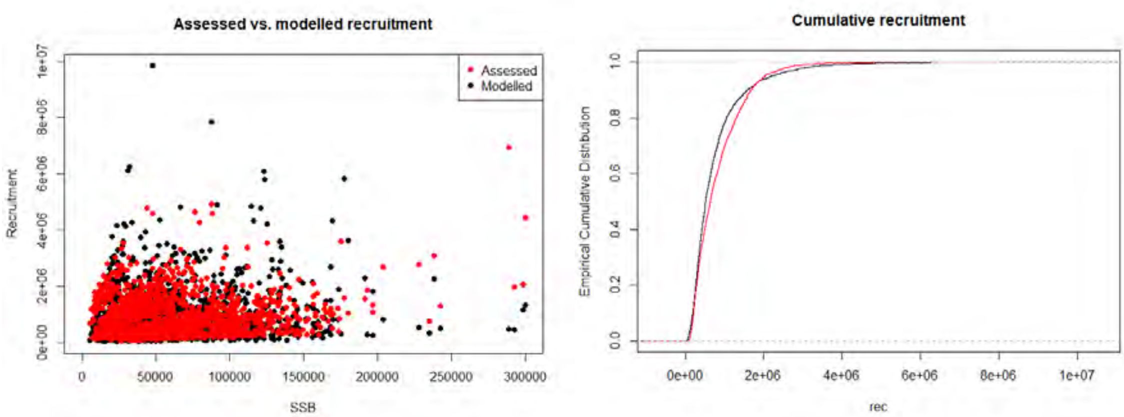

Figure A4.3 A comparison of historic (red) and future recruitments (black) for the stock–recruit pairs shown in Figure A4.2. On the left hand side plot historic recruitment points and generated recruitment for the same SSB values are represented. An empirical cumulative distribution function (ecdf in R) is shown on the right.

San Francisco Bay Pacific Herring Spawning Stock and Commercial Fishery Management Overview

March 2017
Final Report

California Department of Fish and Wildlife
Aquaculture and Bay Management Project
Herring Management and Research
Marine Region, 5355 Skylane Blvd. Suite B
Santa Rosa, CA 95403

Table of Contents

Introduction

The California Department of Fish and Wildlife (Department) has conducted herring research in San Francisco Bay as part of its ongoing monitoring and management of the commercial fishery since 1972. The Department uses annual vegetation dive surveys and individual spawn deposition surveys to calculate a spawning stock biomass estimate each year. It also uses commercial fishery and research mid-water trawl and gill net survey data to estimate the age class structure, sex composition, and general condition of the spawning population each season.

In July, 2011, the San Francisco Bay Herring Research Association contracted with Cefas to develop a stock assessment model for the herring population in San Francisco Bay that would build upon existing scientific and commercial fishery data. The goal of the assessment is to provide an objective basis for managing the stock. In October 2016, the Department hosted a two-day peer review workshop where a panel of experts was assembled to evaluate the stock assessment and operating models for the San Francisco Bay Pacific herring fishery. The peer review committee (Committee) made a number of recommendations for changes to the report structure, requested a description of input data, asked for revisions to the model structure, and additional analyses or justifications for modeling decisions. The Department and Cefas have made every effort to address those areas in the below description and attached stock assessment report.

Management Strategy Evaluation

The Committee was asked to determine whether the stock assessment model "is appropriate and sufficient for use in managing the Pacific herring fishery in San Francisco Bay via incorporation into the Fishery Management Plan for this fishery." Based on this request, the Committee made a number of recommendations for how to improve the Management Strategy Evaluation (MSE) to ensure stock assessment robustness prior to its use in management decisions. A comprehensive MSE analysis that incorporates the review committee's suggestions for herring in San Francisco Bay is currently under way. The goal of this analysis is to establish a management strategy (comprising current data collection protocol and a harvest control rule to set quotas) that adheres to the precautionary management approach of the last 10 years. The MSE will include robust assumptions and address likely uncertainties.

The team conducting the MSE analysis has conditioned a simulation model on the revised version of the Cefas model, and is currently testing a management strategy that uses spawning biomass estimates from the Cefas stock assessment against other, less complex spawning biomass estimation methods. For these tests, the Cefas assessment has been embedded within the simulation model to assess the effects of model uncertainty and misspecification. The MSE team is currently working with various stakeholders to craft a broad range of performance metrics that reflect management objectives and risk tolerances, over short and long time periods. While the current analysis considers the revised Cefas model to be the base case operating model, the MSE team is also testing the performance of each management strategy under a range of uncertainty scenarios, including alternate stock recruitment relationships, cyclical behavior in productivity, as well as including future climate change scenarios that could impact herring.

While we understand that having the results of the analyses described above would vastly improve the ability of the review committee to determine whether the Cefas stock assessment model is sufficient for use in management, the additional work required to complete that analysis was beyond the scope of the Cefas contract and is currently being conducted under separate contract as a key element of the FMP process. The Department requests that the review committee confine the majority of their review to the Cefas stock assessment itself and whether it represents a defensible operating model given the available data.

Data Integrity

The Committee recommended the Department establish a process to ensure a single quality-assured, complete data set is adopted for modeling that is maintained for subsequent analyses and updates or revisions should be tracked. The Committee further recommended the Department adopt a stronger policy of documentation detailing each year's surveys and monitoring in timely internal reports. Each dataset used in the model is appended to the Cefas report (Appendix 1) and is maintained and archived on Department workstations at the Santa Rosa field office.

Data Used for the Analysis

The following sections describe field survey methods, the data that were provided to Cefas by the Department, and the subset of data that were used for the stock assessment model. Three types of fishery-independent surveys were employed to produce these datasets: spawning deposition surveys, which are used to determine spawning-stock biomass; young-of-the-year surveys, used to determine annual recruitment; and population mid-water-trawl surveys, which were used to estimate age composition of the spawning-stock biomass. Fishery-dependent surveys of commercial landings yielded tonnage data, and biological samples from the commercial catch provided commercial age composition data. Each data source is described in detail below.

Fishery-Independent Surveys

Spawning Deposition Survey

The Department began conducting spawning deposition surveys during the 1973-74 season to estimate the number of eggs deposited around the bay as herring move into spawn (Spratt 1981; Watters and Oda 2002). The spawn survey was designed to estimate the total number of eggs spawned and to convert that estimate to the total tons of adult spawners, using a conversion factor based on fecundity. The area of the spawn is measured and samples are collected from which the density (number of eggs/m^2) of eggs is calculated. This is expanded to the total area of the spawn to estimate the total number of eggs spawned. The total eggs spawned is then converted to tons of adult spawners. These estimates were used, along with commercial landings data, to estimate the total spawning-stock biomass (SSB) in each year. During the early years of the fishery the sampling protocol evolved with increased understanding of San Francisco Bay herring spawning biology. During the 1982-83 season, the methods used to convert the number of eggs

spawned to tons of herring was also altered to include information on sex ratio and fecundity data for individual spawning runs, improving the accuracy of the estimate (Spratt 1983).The sections below describe the evolution towards the current sampling protocol, which has been employed consistently since the 1982-83 season with only minor modifications to the area searched and length of season in response to the expansion of herring spawning times and locations over time (Watters and Oda 2002).
Beginning with the 1973-74 season searches for intertidal Pacific herring spawn activity were conducted from a small boat approximately 2-4 days per week during low tide periods, from December to mid-March (Spratt 1981; Watters and Oda 2002). Starting with the 1996-97 season, the search period was expanded slightly to include November and all of March. Spawns were also surveyed outside of these periods, when anecdotal reports were received. When intertidal spawns were located, the area of the spawn was estimated, and a two-stage random sampling plan was then used to collect eggs and estimate the average density for the spawning area. Sites were also sampled opportunistically depending on a variety of factors, including safety, access, tidal height and available daylight. Spratt (1981) and Watters and others (2004) contain a detailed description of the intertidal sampling protocol, but in summary, the length of shoreline was marked and measured on Coast and Geodetic Charts or using a Global Positioning System (GPS) and the width of the spawning area was estimated. Area expansion factors based on habitat type were applied to account for slope and irregularity of surfaces. The shoreline was divided into sections, and 10cm^2 subsamples were selected, and all eggs and algae were removed from each subsample. The number of eggs in each subsample was estimated by weighing the eggs in that portion, and calculating the number of eggs in the subsample. Then the density of egg deposits for each section was calculated by averaging value from the subsamples. The total number of eggs for each area was then calculated by multiplying the area by the average spawning area.

Beginning with the 1979-80 season, Department staff found large areas of subtidal spawning in San Francisco Bay that was not being accounted for in spawn estimates. Prior to this time it is likely that large subtidal spawns went undetected, and the spawning estimates from earlier years are likely an underestimate of the entire spawning biomass. For subtidal spawns, estimates of vegetation density are needed to calculate spawning biomass from subtidal spawns. Subtidal vegetation samples are collected prior to the season from spatially-random sampling locations within beds composed primarily of the red alga, *Gracilaria* spp., and eelgrass, *Zostera marina*, at known spawning areas around the bay. At each sample site, scuba divers collect one sample from each of four ¼ square-meter quadrats. Samples are processed in the lab, weighed, and averaged to estimate vegetation density (kg/m^2).

When subtidal spawning occurs, samples of vegetation with eggs are systematically collected within the spawn boundaries, during the process of locating the edges of the spawn area. A weighted rake is dragged along the bottom from a research vessel to collect vegetation and eggs throughout the bed to determine the extent of the spawning area and to obtain an egg deposition sample. Each 'rake toss' is documented as a 'waypoint' with a GPS unit. Additionally, the absence or presence of vegetation and type, as well as quality of spawn deposition on the vegetation, are recorded on field data sheets for each rake drag. The GPS waypoints are input into a geographic information system, where they are analyzed along with vegetation and deposition attributes to calculate the areal extents of each spawn event. As with the intertidal spawn samples, the subtidal sample is processed in the lab to calculate the number of eggs per kg of vegetation. This data along with estimated vegetation density and estimated extent of the spawning area yields the total number of eggs deposited during the spawn event.

Beginning in 1981-82, herring were also observed to spawn on pier pilings. Pier pilings are sampled using a protocol similar to that for intertidal spawns (Spratt 1984). Pier pilings are sampled randomly due to accessibility and 10cm^2 samples of eggs are collected where possible. The area of spawn is calculated by multiplying the number of pilings by their circumference, then multiplying by the depth of the spawn. Spawn depth is estimated subjectively based on bottom depth shown on the research vessel depth sounder; the density of eggs, and the deepest depth that eggs could be scraped from the piling.

Hydroacoustic Survey

Between 1981 and 2003, the Department also conducted hydroacoustic surveys using a Department research vessel. Surveys were conducted during slack tides (usually high) to reduce error due to tide-related school movement. Herring schools were initially located and qualitatively surveyed with a fish finder and confirmed by sampling with a mid-water trawl. Once the school was verified as herring, quantitative hydroacoustic surveys were conducted with a paper recording fathometer. During this time period when both methods were used, the total spawning biomass estimate was calculated by meshing the results of the hydroacoustic and spawn deposition surveys. If there were constraints for one of the surveys (i.e. equipment failure, missed school or spawn), then the biomass estimate from the other survey was used for that spawn.

In 2003, the Department commissioned an independent review of the hydroacoustic and spawning deposition surveys (Geibel 2003). This review examined how well the spawning biomass estimate from each method correlated with the following year's spawning biomass estimate with the assumption that an estimate of one season's spawning biomass is a good estimator of the spawning biomass in the next year. The review found that while the spawning deposition surveys could explain 50 percent of the variation seen from year to year, the hydroacoustic surveys could only explain 4 percent, and the two surveys were not significantly correlated with each other. Based on the results of the review, the Department discontinued the hydroacoustic surveys and has since relied only on the spawning deposition surveys to estimate biomass and set quotas.

SSB Data used by Cefas

Yearly estimates (in short tons) of SSB from the spawning deposition surveys beginning in 1973-74 through 2013-14 were provided to Cefas for use in the assessment model. These are referred to in the Cefas report as SSB estimates (see Table A1.5 on page 54), but note that they reflect only estimates derived from the Department's spawning deposition surveys, as described above, and do not include the addition of commercial landings or the hydroacoustic survey estimates. Note also that estimates from 1973-74 through 1991-92 were not included in the assessment model, a decision made by Cefas to ensure temporal consistency among the various data sources that served as inputs. Specifics regarding the estimation of numbers-at-age for the SSB are addressed below in the section 'Age Composition Data Calculations'.

Young of the Year (YOY) Survey

Data on the abundance of young of the year (YOY) herring (age 0) throughout the year in San Francisco Bay are available as part of the Department's San Francisco Bay Study. This program began in 1980 with the goal of determining the trends in abundance and distribution of fish and macroinvertebrates in relation to environmental variables in San Francisco Bay. A Department research vessel fishes a mid-water trawl and an otter trawl year-round at each of 52 open-water sampling locations. These locations are sampled monthly and range from southern San Francisco Bay through San Pablo and Suisun bays and into the Delta. Juvenile herring and other species are caught in a mid-water trawl, which has a 3.7 m^2 mouth and meshes that graduate from 20.3 cm at the mouth to 1.3 cm at the cod end. The mid-water trawl is towed with the current for 12 minutes and retrieved obliquely, sampling the water column from bottom to surface. All fish are identified to species and enumerated, and up to 50 fish and 30 crab of each species are measured before being returned to the water (Orsi 1999). These data, along with the volume of water swept, are used to calculate a monthly abundance index of juvenile herring observed in the San Francisco estuary. Monthly YOY indices from 1992-93 through 2013-14 were used to calculate annual recruitment indices for the assessment model (see Table A1.5 on page 54 of the San Francisco Bay Herring Stock Assessment and Initial Evaluation of Harvest Control Rules). The 1992-93 start date of this dataset chosen by Cefas for inclusion into the stock assessment model coincides with the start date of the commercial catch-at-age data used in the assessment.

Population Surveys

The Department has employed surveys to sample the herring population in San Francisco Bay since the 1982-83 season. Surveys typically begin in November when herring schools start moving into the bay, and usually end in March. Trawl or research gill net samples are taken at least once a week, though historically sampling was conducted more frequently when staff levels were higher than today. Department biologists perform on-the-water surveys with the aid of a SONAR fish finder, looking for evidence of herring schools, and opportunistically sampling the schools as they are observed throughout the bay.

Herring population sampling is conducted using two different gear types. A mid-water trawl is the primary method for sampling the adult population. The trawl net has the same design as described in the YOY survey, using a 3.7 m^2 mouth and meshes that graduate from 20.3 cm at the mouth to 1.3 cm at the cod end. However, multi-paneled gill nets are also used when the mid-water trawl survey vessel is unavailable or when fish are in areas too shallow for the mid-water trawl gear to operate. The multi-paneled gill nets are constructed of variable mesh sizes, and include 1¼, 1½, 1¾, 2, 2¼, and 2½ inches to sample the entire range of herring sizes present in the San Francisco Bay spawning population. In many years both types of sampling are used, though in some years only a single method was employed. While the two gear types are likely to have a different selectivity, following a discussion with Cefas, it was decided that all research catch data should be combined in order to create a more complete time series. The removals from the research catch biomass are not included in the stock assessment because these removals only number in the hundreds to a few thousands of fish collected per season.

Fishery-Dependent Surveys

Herring Eggs-On-Kelp Fishery

The San Francisco Bay herring eggs-on-kelp (HEOK) fishery began in 1966-67 with a 5 ton product weight quota which was harvested by divers from wild kelp. The current HEOK fishery uses the open pond method and has been in place since the 1989-90 season. Giant kelp, *Macrocystis pyrifera*, is harvested outside San Francisco Bay and suspended from rafts inside the bay for herring to spawn on in shallow water areas. The product of this fishery is the egg-coated kelp blades that are processed and exported to Japan. The HEOK fishery is allocated a separate quota from the gill net fishery. The harvested product is converted to the equivalent of short tons of whole fish. Landings have historically ranged from 0 to 12.6 percent of the total commercial catch, with an average of 2.8 percent of the total catch each year. These data were not used in the stock assessment because the tonnage associated with these landings represent removed herring eggs, not adult fish. Adult herring are not captured in the HEOK fishery and thus, are able to return to spawn in subsequent years.

Gill Net Fishery

The herring gill net fisheries catch herring as they move into shallow areas to spawn. The traditional product from this fishery, *kazunoko*, is the sac roe (eggs) removed from the females, which is processed and exported for sale in Japan. California's roe fishery began in the 1972-3 season and a formal limited-entry permit system was implemented in 1977. In San Francisco Bay, the fishery is separated into Even and Odd fishing groups (platoons) based on permit numbers. Platoons rotate fishing weeks throughout the season.

In the 1980-81 season, the Commission opened a December gill net fishery (with separate permits and quotas) in San Francisco Bay. Due to a variety of factors, the fishery has not landed herring since December 2006 and beginning with the 2010-11 season permits from that fishery were incorporated into the Odd and Even platoon fisheries which fish from January through March.

Commercial landings data (in short tons) have been collected via landing receipts each season since the roe fishery began in the winter of 1972-73. Through the history of this fishery round-haul (purse seine and lampara) and gill nets have been used in San Francisco Bay to catch herring. Each gear type had separate quotas. Lampara gear was phased out after the 1987-88 season, and purse seine gear was prohibited after the 1997-98 season, which followed a 5-year conversion period.

Over time the minimum gill net mesh size used in San Francisco Bay has varied due to proposals by both the Department and commercial fishery representatives (Table 1). In the

1976-77 season, a minimum mesh size of 2 inches and a maximum of 2½ inches was established for the roe fishery. In 1982-83, the minimum mesh size was increased to 2¼ inches for any fishing prior to January 14, with the option to authorize mesh sizes of 2⅛ or 2 inches for fishing after that date by the Department. The following year this was changed so that the December fishery had a minimum mesh size of 2¼ inches, while the Odd and Even gill net fleets both had a minimum mesh size of 2⅛. In the 1984-85 season, a minimum mesh size of 2⅛ in was established across all fleets in San Francisco Bay, and this remained unchanged until the 2005-06 season, when regulations were changed to decrease the minimum mesh size for gill net fleets in San Francisco Bay from 2⅛ to 2 inches.

Time Period	Gill Net Mesh Size (inches)	
	Minimum	Maximum
1976 to January 14, 1983 (No restrictions prior to 1976)	2	2 1/2
November 28, 1982 – December 16, 1983	2 1/4	2 1/2
January 2, 1984 – March 11, 2005	2 1/8	2 1/2
December 19, 2005 -- Present	2	2 1/2

Table 1. San Francisco Bay Commercial Herring Fishery Gill Net Mesh Size Summary

The commercial herring fishery on the San Francisco Bay spawning stock is regulated through a catch quota system. The annual SSB estimate, age class structure, condition indices, commercial catch analysis, along with various environmental indicators all serve as the basis for establishing fishing quotas for the next season. Annual fishing quotas are necessary to provide for a sustainable fishery and have historically been limited to a total commercial take not to exceed 20 percent (harvest percentage) of the previous season's estimated SSB. This harvest percentage is based upon the results of a previous peer reviewed model (Coleraine) that assumes stable environmental and biological conditions (Hilborn and others 2003; MacCall and others 2003). Each year, the Department recommends a harvest percentage that is not determined by a fixed mathematical formula; rather, the recommendation is informed by the modeling results and takes into account additional data collected each season, including: ocean productivity and estuarine conditions, growth rates of herring, strength of individual year-classes, and predicted size of incoming year-classes (i.e., recruitment). In response to poor recruitment or indication of population stress and/or unfavorable oceanographic conditions, harvest percentages for the past ten years have been set at or below ten percent. The Department calculates the exploitation rate, defined as total commercial catch divided by the SSB estimate plus commercial catch, which has ranged from zero to 38.7% of the SSB estimate for the time period between 1992-93 and 2013-14 (Figure 1).

Landings data from 1972-73 through the then-most-recent season (2013-14) were provided to Cefas for development of the stock assessment. However, for consistency and to match the commercial age composition model inputs, the decision was made to only include landings data back to 1992-93 in the assessment model. Landings are available by individual gear type, but were combined for use in the assessment model. In addition to tracking total landings, the Department samples individual fish caught in the fishery. These data are used to estimate annual age composition for the commercial fishery, and were used by Cefas as inputs to the assessment model. The section below provides specifics on calculating age composition of the commercial catch.

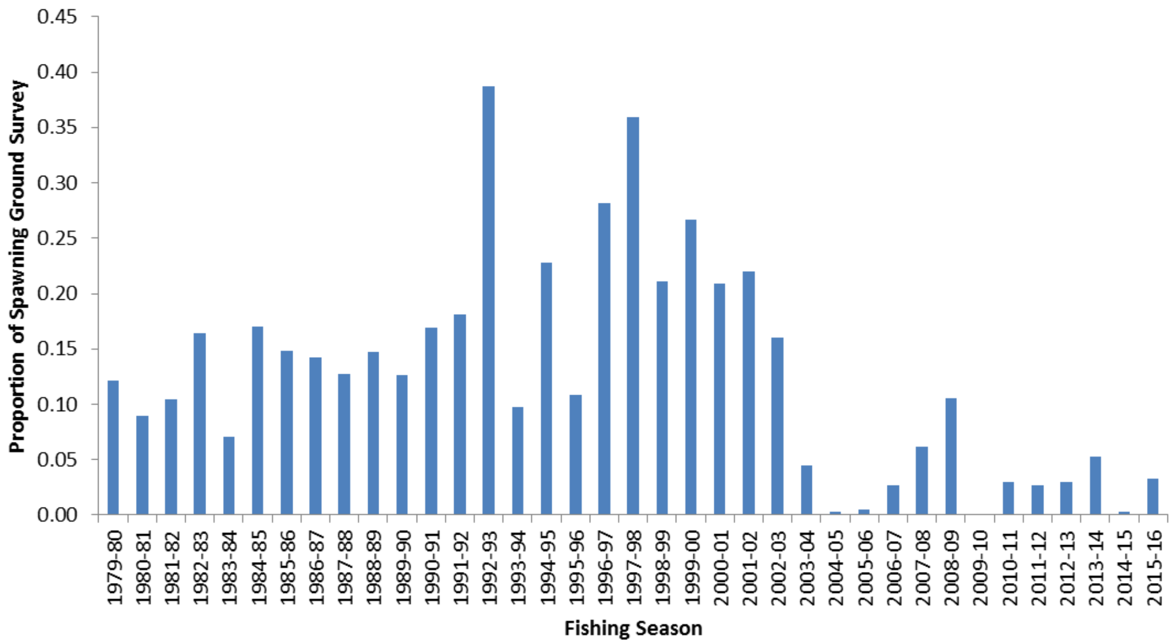

Figure 1. San Francisco Bay Pacific herring commercial roe fishery exploitation rates, landings tonnage as a proportion of spawning ground survey

Recreational Fishery

The recreational fishery is comparatively small and widely dispersed due to the spawning behavior of herring in San Francisco Bay. As a result, few recreational herring fisherman have been sampled in the Department's recreational fish surveys and no data are available on removals that could be included in the assessment model.

Age Composition Data Calculations

Age composition data used by Cefas to condition the assessment model are produced by Department staff from both fishery-independent and dependent biological samples, termed 'research' and 'commercial', respectively. As described above, the research data are obtained by Department staff using mid-water trawl gear and multi-panel gill nets. Commercial catch is sampled by Department staff as the fish are landed as well as directly from fishing vessels during fishing operations. Fish with ripe gonads from research samples are used to determine age composition of the SSB, and all fish sampled from the commercial landings are used to determine age composition of the commercial catch.

Length and maturity data are recorded for all sampled fish. For research samples weight data and otoliths are only collected from the mature fish, however these data are collected for all commercial herring sampled. All removed otoliths are surface aged at the end of the season by Department biologists. Proportions-at-age estimated from these samples are used to calculate annual numbers-at-age for both commercial catch and the SSB estimate.

Number-at-age and average weight-at-age data are used to estimate age composition of the SSB and commercial landings. The first step in the process is to associate biological samples with spawning waves or landings events based on temporal and spatial proximity. Once this is completed, number-at-age, mean weight-at-age, and total weights are determined for each sample. The number-at-age is multiplied by mean weight-at-age, and then divided by the total sample weight for the spawning wave or landings to get the percent weight for each age. Percent weight is then multiplied by the spawning wave biomass or commercial landing to calculate short tons at age. Tons-at-age are multiplied by a conversion factor (907,185 grams/short ton) and divided by the mean weight-at-age to calculate numbers-at-age in the commercial landing or spawning wave The tons-at-age and number-at-age for each spawning wave are summed to get the season totals. Total tons at each age are divided by the total weight for all ages to get the proportion of numbers-at-age, which was used in the model. The mean commercial weight-at-age is calculated from the total weight-at-age divided by the total number-at-age, and these data for each season are used in the model.

SSB Numbers-at-Age
The Department has sampled the spawning biomass for age composition and weight data since the 1982-83 season. Prior to the 2003-04 season, age-length keys were used to assign ages to the entire sample. These keys were constructed annually, after ageing a subset of the catch (17 fish per each 10 mm increment for each spawning wave) to assign ages to the unaged portion of the samples. In 2003, the Coleraine stock assessment review committee recommended using direct aging and after the 2003-04 season direct aging of the otoliths was used to determine age composition. The only exception was the 2011-12 and 2012-13 seasons when the length-age key method was used because Department staff did not have sufficient time to age the large number of fish collected.

Note that only a small fraction of age 1 fish are mature, and the model only used data from fish ages 2–6+ for the SSB numbers-at-age data. Also note the age 6+ group includes all fish age 6 and older. Weighted numbers-at-age data from 1997-98 to 2013-14 were used in the assessment. Numbers-at-age data from the period 1982-83 through 1996-97 were not used in the assessment due to time constraints associated with producing the data in the format required by Cefas to develop the assessment model.

Commercial Catch Numbers- and Mean Weight-at-Age
The Department has sampled the commercial catch for age composition and weight data from the roundhaul catch since the 1973-74 season and gillnet catch since the 1976-77 season. Commercial samples of herring are collected opportunistically from waves of herring as they are caught in the fishery. Generally, each sample consists of 10 – 40 fish and

is collected from individual vessels or from fish buyers by landing date. Each sample records length (mm body length), weight (to the nearest 0.1g), sex, maturity, and otoliths for individual fish are removed. Spent or immature fish are typically not caught in the commercial gill net fishery, but because they are a portion of the removals, no herring are discarded from sampling based on their maturity.

Data from the period 1973-74 to 1991-92 were not used in the assessment because the information required to recreate age composition data in the format required by Cefas were not available due to time constraints. Commercial catch age composition and average weight-at-age data from 1992-93 to 2013-14 were recalculated using the method required by Cefas (see Age Composition Data Calculations, above) and used in the assessment.

Literature Cited

Geibel JJ. 2003. Comparison of herring egg spawn biomass estimates and hydroacoustic biomass estimates. California Department of Fish and Game.

Hilborn R, Maunder M, Parma A, Ernst B, Payne J, Starr P. 2003. Coleraine: A generalized age-structured stock assessment model - User's manual version 2.0. University of Washington, School of Aquatic and Fishery Sciences. No. SAFS-UW-0116.

MacCall AD, Maunder M, Schweigert J. 2003. Peer review of the California Department of Fish and Game's commercial Pacific herring fishery management and the use of the Coleraine fishery model.

Orsi J. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary. Interagency Ecological Program. IEP Technical Report.

Spratt JD. 1981. Status of the Pacific herring, Clupea harengus pallasii , resource in California 1972 to 1980. California Department of Fish and Game.

Spratt JD. 1983. Biomass estimates of Pacific herring, Clupea harengus pallasi, in California from the 1982-83 spawning ground surveys. California Department of Fish and Game. Marine Resources Administrative Report No. 83-3.

Spratt JD. 1984. Biomass estimate of Pacific herring, Clupea harengus pallasi, in California from teh 1983-84 spawning ground surveys. California Department of Fish and Game. Marine Resources Administrative Report No. 84-2.

Watters DL, Brown HM, Griffin FJ, Larson EJ, Cherr GN. 2004. Pacific Herring Spawning Grounds in San Francisco Bay: 1973–2000. American Fisheries Society Symposium 39:3-14.

Watters DL, Oda KT. 2002. Pacific herring, Clupea pallasi, spawning population assessment and fishery management for San Francisco Bay, 1993-94. California Department of Fish and Game. Marine Resources Administrative Report No. 02-1.

Review of the Revised Stock Assessment for the Pacific Herring Population in San Francisco Bay

May 16, 2017

Both the Cefas analysts and CDFW staff have done a good job of addressing a number of concerns raised by the Review Panel regarding the preliminary assessment of the San Francisco Bay herring population. In particular, the Panel notes big improvements in the documentation of the methods used in data collection and compilation, the description and presentation of equations used in the model formulation, and the explanation of the simulations. We wish to especially note the very important March 2017 management overview, produced by California Department of Fish and Wildlife, and specifically acknowledge the importance of this history. In addition, Cefas analysts conducted a number of additional assessment runs to test alternative model formulations and provided figures and tables with likelihood estimates and plots of the results. Although the Cefas report is very much improved, and many of our criticisms have been addressed, we did find some of the same deficiencies that were pointed out in our previous review. Moreover, after reviewing the latest draft, the Review Panel found itself somewhat unsure of our mission and somewhat confused by the goal of the review.

Cefas has clearly stated in the new discussion, "the MSE framework and HCRs presented are preliminary and have not been fully developed here." We agree with that conclusion and take note of it. We also acknowledge the request from CDFW to limit our review to "the Cefas stock assessment itself and *whether it represents a defensible operating model given available data* (emphasis added)." The conclusion that this model is not "fully developed" seems to answer the question as to whether or not the assessment represents a "defensible operational model." The analysis under review, as the Panel understands it, appears to be a single model based on a combination of assumptions and model fits to data. This exercise has been very useful in identifying several scientific questions that remain about San Francisco Bay herring dynamics. But, because so many questions remain, we cannot agree that a single model—that in some sense might be the best—can be used to reliably predict the actual dynamics of the herring stock.

The available data have not been sufficient to resolve a number of issues. These data are not sufficient to develop a clear picture of the relationship between stock size and subsequent recruitment—especially at small stock sizes. After considerable work, the relationship between fish age and gear selectivity has not been clearly defined. The question of whether or not the 2007 *Cosco Busan* oil spill affected the stock productivity to a substantial extent remains, as do questions about the best way to model variation in recruitment in the years potentially affected by the oil spill. The Cefas analysts found reasons to adopt Model 6 as their base model. The Review Panel, on the other hand, can see many reasons to delete either the oil spill factor or the somewhat ad hoc mortality multiplier for the age-6+ group, which we will discuss below. Either way, the application of data to the modeling process has resulted in controversy and uncertainty. Moreover, that uncertainty should be reflected in the larger MSE process by considering Model 6 along with a range of other operating models that consider alternative hypotheses. That uncertainty cannot be adequately captured and communicated by simply focusing on any single model that might, in some sense, be the best.

Modeling Issues

The stock-recruit relationship remains an issue with respect to the defense and validation of the proposed operating model. A large amount of the revised report is devoted to estimating the stock-recruit relationships. In the end, the available data simply do not support any particular, biologically reasonable stock-recruit relationship. It may be that there is simply too much measurement error in either the stock size estimates, the recruitment estimates, or both for the stock-recruitment relationship to be statistically determined. In any event, after considerable manipulation of stock-recruit data, the stock-recruitment relationships used in all of the proposed models are principally a matter of just assumption. If there is decreased recruitment at low or moderate stock sizes, measurement error may be obscuring the actual stock-recruitment relationship[1]. It needs to be emphasized that the assumption around the form of the stock-recruit relationship is critical to the dynamics of the population in any simulation scenario of future productivity and resilience and will affect any decision about an optimal harvest control rule.

The Cefas authors dismiss the dome-shaped selectivity function that was observed in Model 1 because it led to apparently excessive numbers of fish in the age-6+ group. However, given that the fishery has used only gillnets since 1999 (Figure 4 in the revised report), and this being a very selective gear targeting particular size groups of herring, one might expect the domed selectivity function that is evident here in the plots. To address the apparent surplus of fish in the age-6+ group, a flat-topped selectivity function was inserted for the age-5 and -6+ groups. Importantly, this flat-topped model does not appear to select any fish of age 2 (see Figure 14). However, in Table A1.3 we note that there are substantial catches of age-2 fish in many years. Therefore, the selectivity function in the base model appears to be incorrect or at least unrepresentative of the available data. Additionally, the likelihoods for Model 1 in both Tables 4a and 4b (355.81 and 357.54) are equivalent to that for Model 6 (357.76). In our view there is no justification for adopting the more complex Model 6, or at least that justification cannot be based on improved fit to available data.

As noted above, large numbers of age-2 fish are mature and captured in the fishery, and likely virtually all age-3 herring are mature (based on the research selectivity curves). Therefore, we suggest that a selectivity function that is fixed at 1 for all fish aged 3 and older would be a more realistic reflection of San Francisco Bay herring and the selectivity of the gillnet fishery. It is almost certain that such a function would deal with the issue of an accumulation of fish in the age-6+ group, the so-called “cryptic” biomass.

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[1] See Hilborn, R. and C.J. Walters. 1992. *Quantitative Fisheries Stock Assessment*. Chapman Hall, pages 287 to 290.

The Panel remains unconvinced that an ad hoc adjustment for the oil spill is justified, and we remain concerned about model over-fitting. We note that there has been a multitude of studies of potential oil impacts on the herring population in Prince William Sound and there has been no conclusive evidence of any negative short-term impact on the population. While the *Cosco Busan* oil spill was somewhat different in that it was a spill of refined petroleum product, it is evident from oceanographic data that both 2005 and 2007 were very unusual years in the eastern Pacific Ocean. Unusual ocean conditions may have played a role in the apparent mortality event associated with the oil spill. Not unexpectedly, the addition of more parameters into the model (oil spill effect) will result in a better fit of the model to data and the appearance of reduced variability in recruitment. However, we did not find adequate justification in the report to include this effect in the model.

Other data issues

We were also surprised to learn that much of the age composition data are derived from an age-length key prior to 2003. This led us to wonder whether this may also be a partial explanation for the apparent "cryptic" age-6-and-older biomass. In particular, Chilton and Stocker[2] report that surface aging of otoliths—rather than break-and-burn methods—typically resulted in lower age readings for herring. Therefore, an age-length key based solely on surface aging would be expected to under-represent the existence of any individuals in older age classes. It seems at least possible that there may be some individuals age 10 or older, as is observed in other Pacific herring populations, which could also account for some of the "cryptic" biomass.

On page 46 of the revised report, the analysts comment on the question of relative weighting of age composition versus abundance index data and discount reduction of the weight on the age composition data but provide no clear explanation. Given the fact that much of the age composition data derives from the application of an age-length key, and the uncertainty in ages associated with surface ageing versus break-and-burn techniques, we believe that the high confidence placed on the age composition data is unwarranted and likely results in overfitting of the model to the age composition data. Further it is difficult to believe that the spawn index data, which are the only empirical estimate of the SSB for this population, and which CDFW uses directly to set harvest quotas are given less weight in the likelihood function than all of the other data inputs. In any event, Francis[3] describes statistical methods for determining the weightings on the various data sources and should be applied to properly weight the data inputs.

Model Selection

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[2] Chilton, D. E., & Stocker, M. (1987). A comparison of otolith and scale methods for aging Pacific herring. North American Journal of Fisheries Management, *7*(2), 202-206.

[3] Francis R.I.C.C. (2011) Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68: 1124–1138.

The mortality multiplier for age 6+ is evaluated in Table 7. It presents the results of a number of alternative model fits using other natural mortality formulations as presented in Models 10 to 13. They all produce similar likelihood values to the baseline model. We note that Model 13, which is discounted, still has a significant function gradient. The likelihood function for Model 13 (omits 6+ group mortality multiplier) is at a local rather than global minimum, so this effect cannot be tested by this run. However, Model 12, which also omits the age 6+ mortality multiplier, results in the same likelihood function value as the base Model 6, seeming to indicate that this mortality multiplier does not really improve the model fit.

In Table 9, the results for Model 19 relative to Model 6 (models differ due to adding additional years of data) change the perspective on the population substantially. The unfished abundance increases from 74,000 to 85,000 and the estimate of the proportion of the population observed by the spawn assessment surveys decreases from almost half to about one third (q=0.449 to 0.341). We find this sensitivity to the model fitting due to the addition of small amounts of data troubling and may be a function of the disproportionate weighting of the age composition data relative to the spawn and recruit index information.

In Table 18, the results of increasing the proportion of fish mature at age 2 are presented and show a slight decrease in likelihood function value, suggesting a very slight improvement in fit to the available data. The result is discounted because it is "difficult to compare model fits because of the change in underlying data." While that may be true, there is a widely held understanding that there is a cline in maturity of Pacific herring in moving from Alaska to California, with more fish maturing at younger ages as one progresses southward. One would expect that more herring are mature at age 2 than has been assumed in the base model and this is evident from catches in the commercial fishery. Very few age-2 herring are seen in any British Columbia or Alaska fisheries but it is maturity data from BC that are the basis for the maturity function applied in the base model here. We believe that applying a more realistic selectivity function using the known or assumed maturity ogive will lead to a better fit to the available age composition data.

Assessing the Harvest Control Rule and Risk

In the MSE context, any model that can be defensibly conditioned on historical data is appropriate to *consider* as an alternative hypothesis about the historical and future population dynamics. The data fitting procedures used in conditioning such models should provide some measure of the relative degrees of credibility for each of the operating models. In the MSE context, this credibility should be used to rank model predictions at a later stage in the process. Accordingly it is not really appropriate to ask that the Review Panel confine their review to the single Cefas preferred model, and then ask whether it represents a (single) defensible operating model given the available data. Cefas has provided several alternative models that could be used as operating models as long as their relative plausibility can be ranked[4]. An additional measure of plausibility, that should be part of a complete analysis, has to do with how well the simulations reflect the experience managing other herring populations in the Pacific.

The Panel strongly agreed that the Cefas preferred model (Model 6) by itself should not be assumed to realistically simulate all aspects of the dynamics of the actual San Francisco Bay herring population for the purpose of managing the fishery in this or subsequent years. While the Panel noted the comments about testing "each management strategy under a range of uncertainty scenarios" on page 3 of the management overview provided by CDFW, the Panel was left to wonder which management strategies were being entertained and to wonder how uncertainty was introduced into the simulations. If it is safe to assume that such uncertainty scenarios included an alternative operating model, then the alternative operating models will need to be ranked by their plausibility.

Regardless of the range of operating models being proposed, we view that it is essential that the current management strategy be tested along with the range of other strategies. Certainly a facsimile of the current management strategy, together with the Cefas assessment model, should be tested alongside other alternatives. While the management strategy has varied somewhat from year to year, it is important to consider the historical experience of applying the current management strategy: its use, in this case, defined by a range of exploitation rates from 0-38%, with exploitation rates since 2000 of less than 20%. The experience so far demonstrates that, when used with the harvest control rule, this has not resulted in depletion of SF Bay herring stocks. Given that history, CDFW should be aware that adopting an operating model that doubles the perceived biomass (given the estimates of q in Table 8), and then uses this assumed higher biomass as the basis for evaluating future management procedures, may seem to justify management procedures that produce higher catch given the same apparent exploitation rates that were applied historically. Unlike the management strategy that has been in place for which there has been some historical experience, there will only be a relatively novel set of simulations to justify adopting this approach.

In conclusion

Perhaps the most troubling aspect of the updated report is the risk assessment presented in Table 10. The forward projection model assumes little or no impairment of recruitment across the range of observed spawning biomass. An assumed fishing mortality rate of 1.0 when combined with the natural mortality rate of 0.63 implies an overall survival rate of about 20 percent of the population but a depletion of only about 53 percent (SSB/K_{SSB}). This does not seem realistic, nor is it consistent with what is known about herring management in other areas. Evidence from other herring populations in British Columbia and Alaska have shown much higher depletion levels at much lower harvest rates. In particular, past experience in British Columbia during the reduction fishery of the 1960s demonstrated that removal rates of 60 percent virtually extirpated the fishable population.

[4] Punt, André E., et al. 2014. Management strategy evaluation: best practices. Fish and Fisheries, 17(2): 303-334.

Further, recent experience in both British Columbia and Alaska with harvest rates of less than 20 percent have shown risk levels (i.e. spawning biomass less than 25% of virgin comparable to B_{lim} used here) much higher than the 6.4 to 7.0 percent risk identified in Table 10. We believe that the operating model used to generate the risk table does not adequately reflect the experience of what has been observed in exploited Pacific herring populations elsewhere and does not reflect what is known about the productivity of the San Francisco Bay herring population.

In our view, there are significant problems with the assessment (operating) model, as one would expect with an analysis that is "preliminary" and not "fully developed." While we acknowledge that this analysis has been valuable as a preliminary investigation, we believe that using it to make projections of the risk associated with fishing the San Francisco Bay herring population at high removal rates will lead to unrealistic estimates of resilience that, if implemented, could result in serious conservation impacts to the resource.

Minor Comments

Page 9 (in the introduction) it is stated here that "annual fishing quotas are necessary to provide for a sustainable fishery and have historically been limited to a total commercial take not to exceed 20 percent (harvest percentage) of the previous season's estimated SSB." The term *estimated* often refers to a quantity derived through a statistical procedure. We are curious as to which quantity was determined through the MacCall et al 2003 peer review not to exceed 20%: the exploitation rate h referred to in Figure 1 is the quotient of total commercial catch C at time t divided by the spawning stock biomass, SSB at time t-1: $h=C_t/(SSB_{t-1}+C_t)$. However, the "harvest percentage" looks like it should be defined as C_t/SSB_{t-1}.

Figure 2 still does not have proper axis labels. Note that the word *April* is misspelled in this figure caption.

Review Panel

Hal Geiger, Chair
Jake Schweigert
Nathan Taylor

Appendix C Coleraine Stock Assessment Model Report

Peer Review of the California Department of Fish and Game's Commercial Pacific Herring Fishery Management and Use of the Coleraine Fishery Model
Completed: August 20, 2003

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Problem Statement

The California Department of Fish and Game (DFG) has traditionally used spawn surveys and hydroacoustic surveys to assess the stock size of Pacific herring in San Francisco Bay. These surveys have demonstrated a steady downward trend in the stock size over the past 25 years. Beyond the downward trend, during the past several years there was disagreement between the population estimates derived by using these two survey techniques. This year (2003) DFG decided to use currently available statistical modeling techniques to further assess the status of the population and the results that might be expected from different management strategies. The selected model, the

Coleraine model, had not previously been used by DFG, and this general purpose model was not specifically designed for assessing San Francisco Bay Pacific herring. DFG requested that California Sea Grant assemble a panel of peer reviewers to determine if it was appropriate to use the Coleraine model, to instruct them in its use, to help its staff in interpreting the results, and possibly to suggest appropriate changes in management strategy. Sea Grant assembled a team of scientists with demonstrated expertise in modeling and assessing fish populations: Alec MacCall; Mark Maunder, and Jake Schweigert. They assembled together with DFG staff for a two-day workshop (August 19 and 20, 2003) designed to accomplish the above stated goals. Following are their findings, conclusions, and recommendations.

Findings

Estimates of stock abundance and trajectory over the available time series by an equilibrium surplus production model, the Coleraine catch-age model, and the Canadian herring catch-age model all result in similar estimates of stock status. The indication is that the San Francisco Bay herring population has been reduced to a level of roughly 20% of the unfished level and is presently at or near the lowest abundance observed since the early 1970s. All data (survey, CPUE, and catch-at-age) are generally consistent with these findings. The exploitation rate defined as catch divided by spawning biomass has been over 20% for most of the period since 1990. The fishery tends to catch a very high proportion of the individuals that are vulnerable to the gear.

The age composition of the catch has changed towards younger individuals. At present there are essentially no individuals aged 6 years or older in the catch, while in earlier years these ages made up over 50% of the catch. Due to higher exploitation rates it is expected that the average age in the catch should have reduced. However, there is substantial evidence that the fishery has increasingly targeted younger individuals. The present mesh size limit in the fishery represents a lower limit for the exploitation of this population allowing a proportion of the age 3 and most of the age 2 fish an opportunity to spawn. Any further reduction in the mesh size or increase in the hanging ratio would negatively impact the population.

The spawn survey tends to underestimate spawning biomass by about 10% and the hydroacoustic survey tends to overestimate the spawning biomass by about 20%. The errors (coefficients of variation) in the annual spawning biomass indices are about 40% for the spawn survey and about 75% for the hydroacoustic survey. This indicates that the spawn survey is a better estimate of spawning biomass than the hydroacoustic survey.

The practice (or tendency) of using the higher value of the spawn survey or the acoustic survey as the basis for setting quotas has contributed to overfishing. The target exploitation rate (catch per spawning biomass) of 20% may be higher than optimal, and also has been exceeded frequently over the past decade. Maximum sustainable yields are obtained using an exploitation rate (catch divided by spawning biomass) of about 16%. Simulation analysis suggests that under the current age-specific selectivity pattern of the gear, this may involve harvesting nearly all the vulnerable individuals depending on the shape of the stock-recruitment relationship (which is not well estimated at the present time).

Recommendations

The San Francisco Bay herring population has been reduced to a level of roughly 20% of the unfished level and is presently at or near the lowest abundance observed since the early 1970s. A rebuilding policy should be implemented.

The current harvest strategy for this stock should be re-evaluated and explicitly documented. The current harvest rate policy of 20% appears to be too aggressive under current levels of stock production. A harvest rate in the range of 10-15% appears to be sustainable with the lower level providing a desirable target for stock rebuilding. The CDFG should investigate the suitability of a fishing threshold or cutoff level similar to that in place in British Columbia and Alaska to conserve spawning biomass and during periods of reduced productivity.

The Department should develop a specialized herring stock assessment model using an approach similar to that in Coleraine. This will make the best use of the variety of data that exists for herring and would better reflect unique biological properties of the San Francisco Bay stock. While this could be done by contract, the Department would benefit greatly by developing this model in-house. This would assure that DFG has staff who understand the techniques and assumptions in such a model, who would be capable of maintaining and updating the model, and who would be capable of applying the technology to other resource management problems.

Spawn surveys provide a sound empirical estimate of current stock size and should be continued on an annual basis as the primary index of abundance and as the biomass estimate for use in setting the fishery quota for the upcoming season until an integrated catch-age model can be developed and verfied. Hydroacoustic surveys should be continued on a developmental basis as resources allow to support the location and timing of spawn assessment surveys and to better understand possible changes in pre-spawning herring behaviour within the bay. Such surveys can be conducted in conjunction with the trawl surveys that are critical for the collection of information on the age structure of the spawning population. The results of this year's Coleraine model runs may provide useful guidance for decision-making, with the understanding that the future specialized model may produce results that differ in unanticipated respects and the two models are unlikely to be exactly equivalent.

The biological sampling program currently in place for estimating the age-structure of the population is not providing an unbiased estimate of the true population age composition. The present system of obtaining age compositions by means of age-length keys should be replaced by direct (random) sampling of ages from the fishery and survey catches. The allocation of age samples would be approximately equal between surveys and fishery catches, and should be based on an approximately constant rate of samples per ton. The DFG may also want to consider the use of scales rather than otoliths to maximize the use of available ageing resources.

We recommend that the Department adopt a stronger policy of documentation. Details of each year's surveys and monitoring should be recorded and archived at least in timely internal reports.

Acknowledgement
We commend the professionalism of the DFG staff in supporting this review. Their dedication to herring research over the past 25 years has made it possible to do the statistical analyses required for sound management.

Appendix D Herring Spawning Habitat Maps

Figure D1. Bays and estuaries in the central California Current Ecosystem with known and potential Herring spawning habitat.

Figure D2. Eelgrass (*Zostera marina*) habitat in the Smith River estuary.

Figure D3. Eelgrass and other habitat types in Humboldt Bay (Schlosser and Eicher, 2012) and Herring spawn coverage.

Figure D4. Eelgrass and other habitat types in the Eel River estuary (Schlosser and Eicher, 2012).

Figure D5. Eelgrass habitat in Ten Mile River estuary.

Figure D6. Eelgrass habitat in the Noyo River estuary (Merkel and Associates, 2016).

Figure D7. Eelgrass habitat in the Big River estuary.

Figure D8. Eelgrass habitat in the Albion River estuary.

Figure D9. Widgeongrass (*Ruppia maritima*) habitat in the Russian River estuary.

Figure D10. Eelgrass and other habitat types in Bodega Harbor.

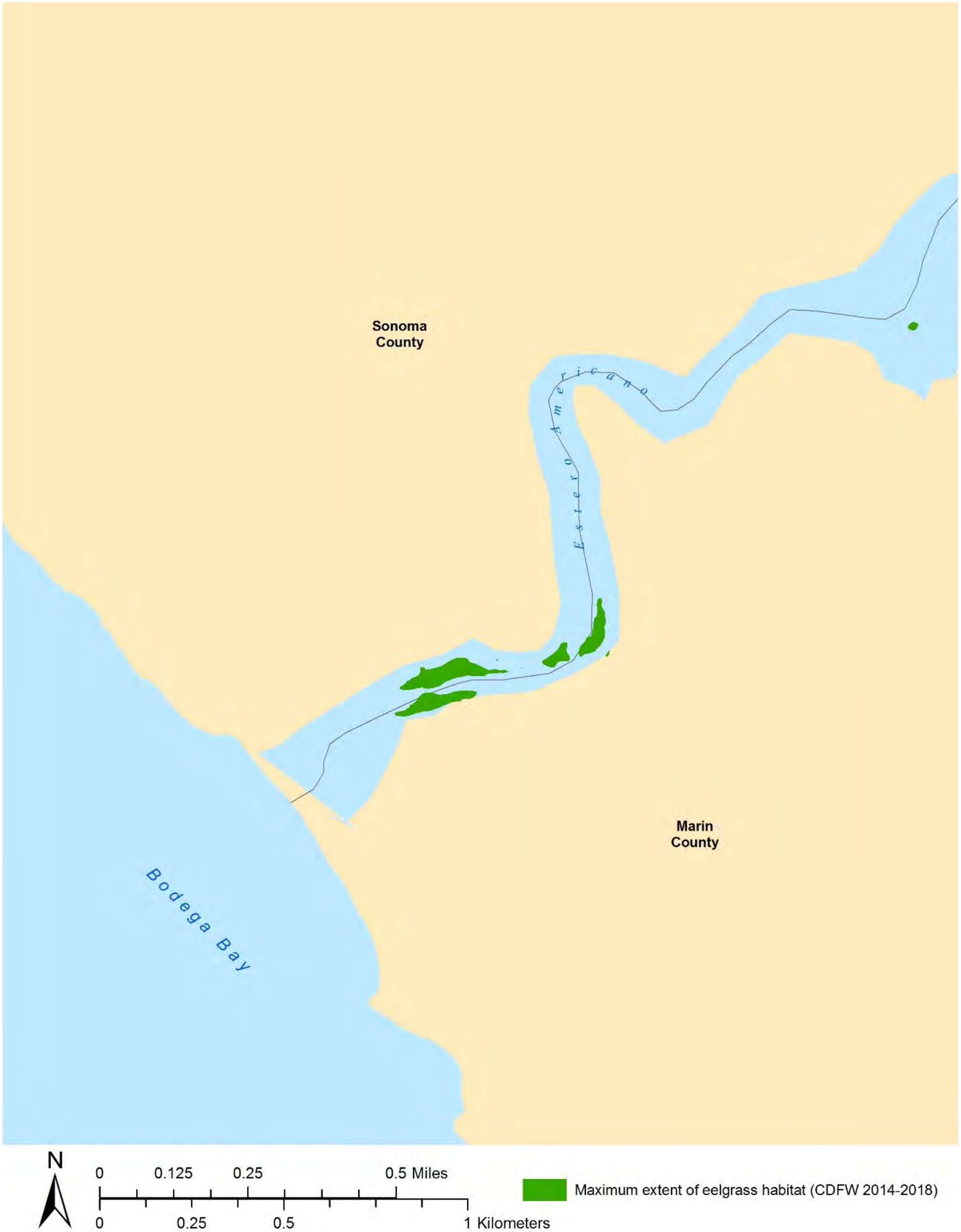


Figure D11. Eelgrass habitat in Estero Americano.

Figure D12. Eelgrass habitat in Estero de San Antonio.

Figure D13. Eelgrass habitat in Tomales Bay.

Figure D14. Eelgrass habitat in Drakes Estero and Estero de Limantour.

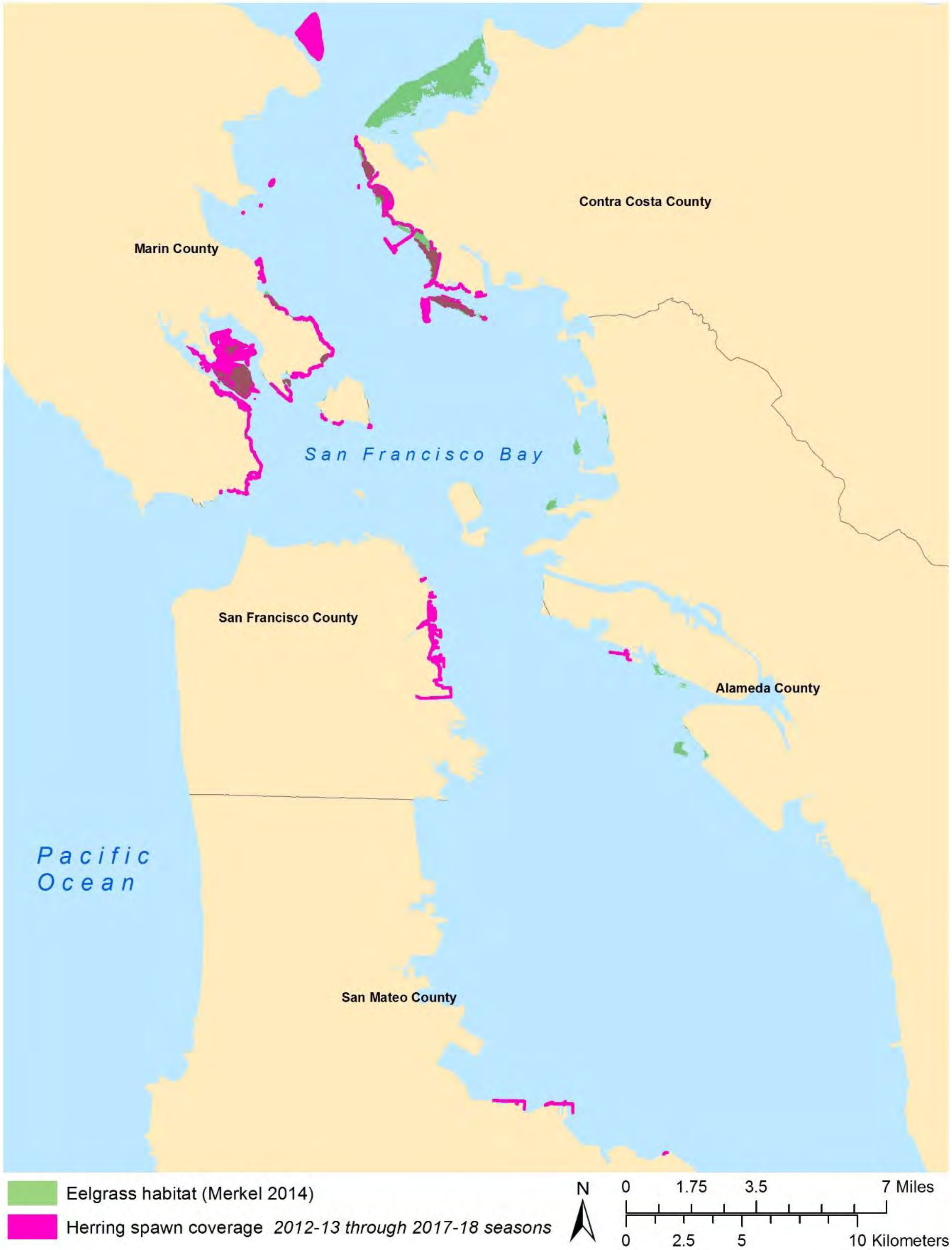


Figure D15. Eelgrass habitat and Herring spawn coverage in San Francisco Bay.

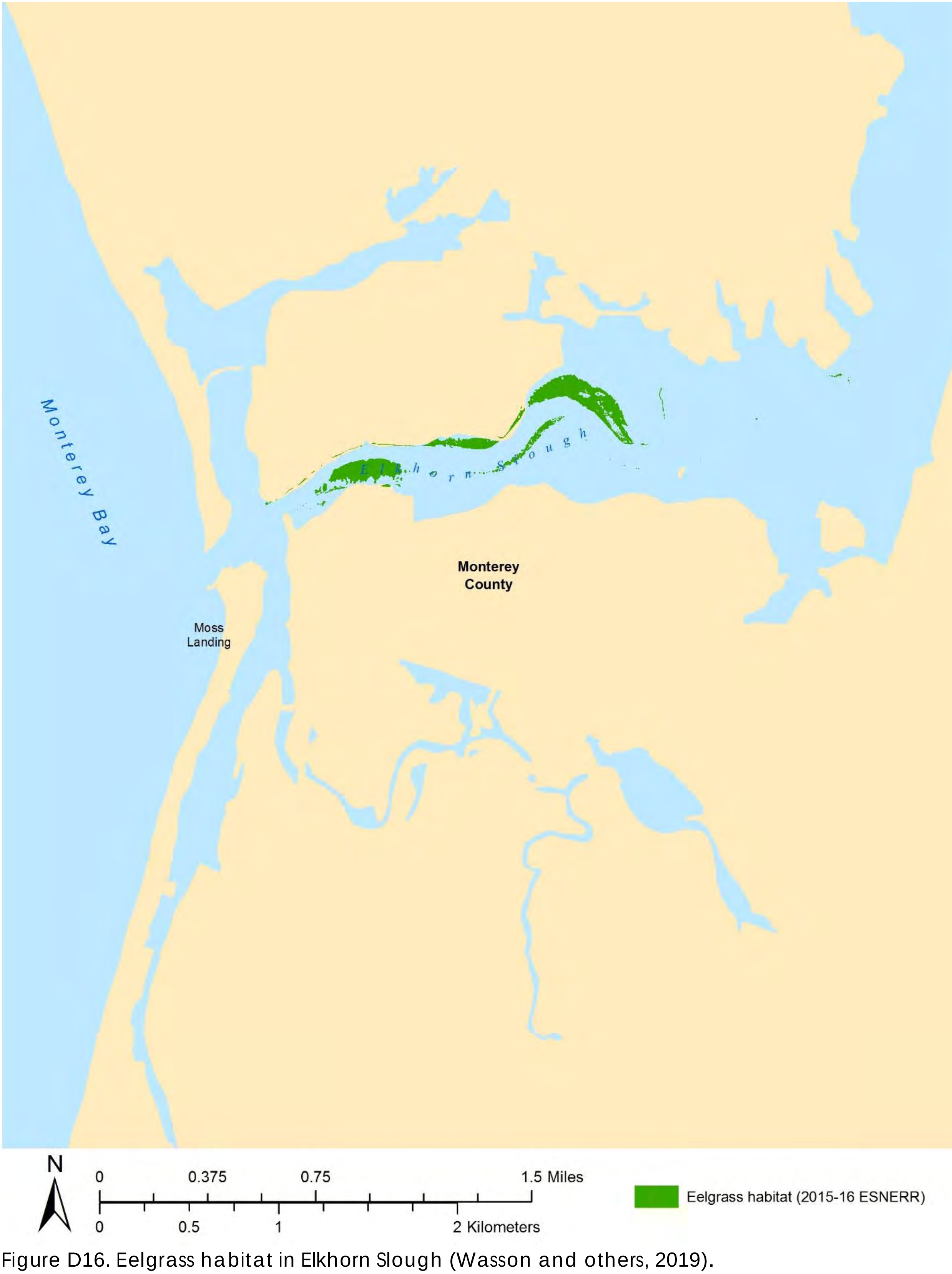


Figure D16. Eelgrass habitat in Elkhorn Slough (Wasson and others, 2019).

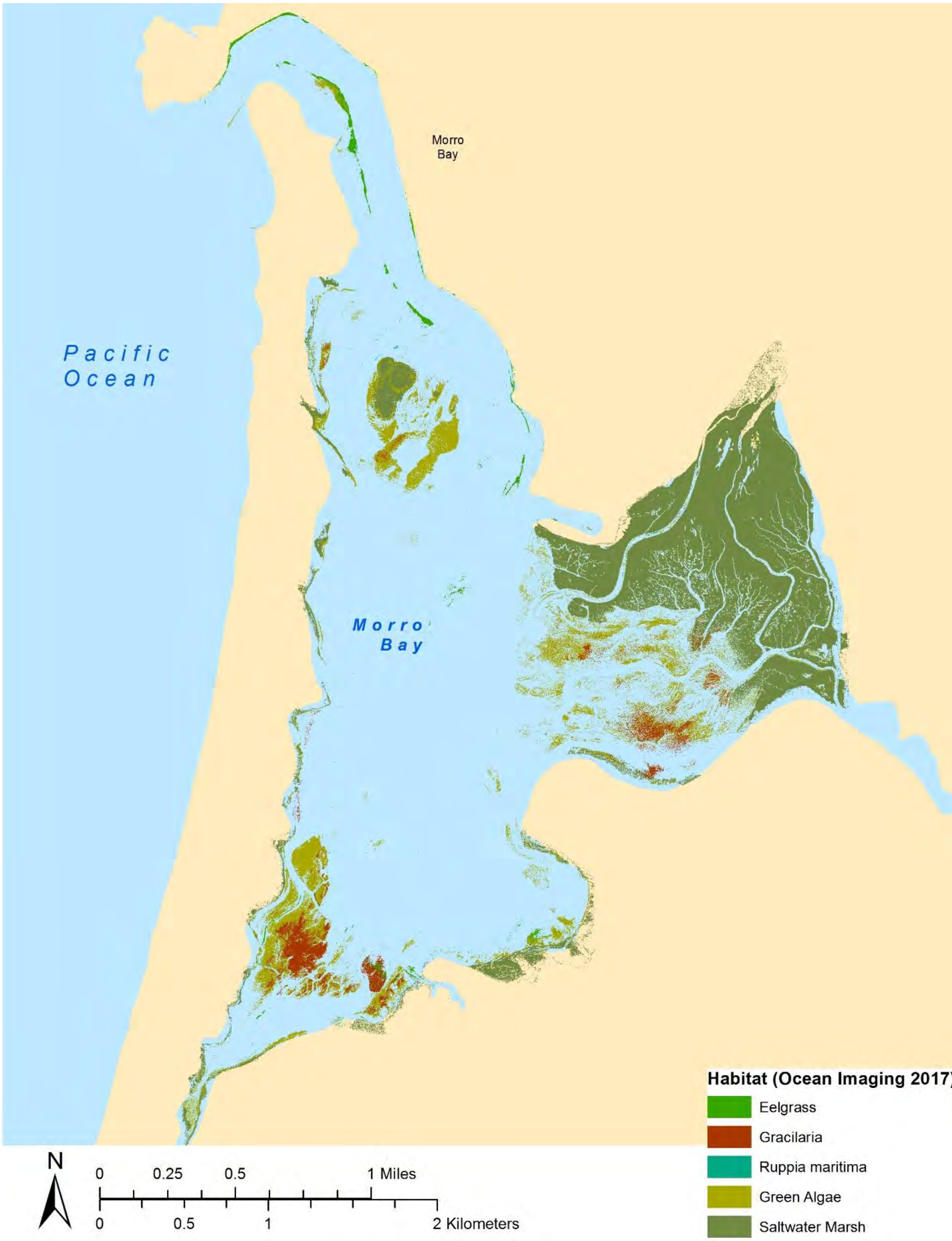


Figure D17. Eelgrass and other habitat types in Morro Bay.

Appendix E Forecasting Herring Biomass in San Francisco Bay

The California Marine Life Management Act (MLMA) requires ecosystem considerations in fisheries management, in this case for the San Francisco Bay Pacific Herring (Herring), *Clupea pallasii,* fishery. Herring exhibit high variation in abundance from year to year, and are thought to respond very quickly to changes in environmental conditions. Previous analyses have had difficulty in developing stock-recruitment relationships due to the high variability, and it was hypothesized that including environmental variables might help managers to identify a relationship that could be used to predict future biomass.

As part of the Fishery Management Plan (FMP) development, the Farallon Institute was contracted to conduct a study on correlations between environmental indicators and metrics of Herring stock health in San Francisco Bay, and to develop a model to predict spawning stock abundance each year. The Farallon Institute is a nonprofit scientific organization that conducts research designed to provide the scientific basis for ecosystem-based management practices. The information below is taken from the report they produced in fulfillment of this contract, and is included as an Appendix in the FMP in support of the proposed management strategy.

The results of this study were also published in Sydeman and others (2018). In that paper, the Multivariate Ocean Climate Indicator (MOCI) (García-Reyes and Sydeman, 2017) was included in the best predictor model of Spawning Stock Biomass (SSB). However, this index is not available before the beginning of each commercial Herring season, when quota decisions need to be made. The Sea Surface Temperature (SST) indicator used here achieved almost as much predictive skill while being available for use in the management process.

Environmental Correlations

Biomass of the San Francisco Bay Herring population has been monitored by the Department of Fish and Wildlife (Department) during the winter spawning season from November through March since the 1970s (Watters and others, 2004) (Figure E-1). The Herring spawning season runs across the calendar year (November through April); throughout this appendix the January year is used to indicate the season (for example, 2018 indicates the 2017 to 2018 season). SSB is based on egg deposition surveys only. All references herein to Herring biomass are reported in metric tons (mt); the Department's reporting system is based on short tons (t) and comparison between the two units requires a conversion.

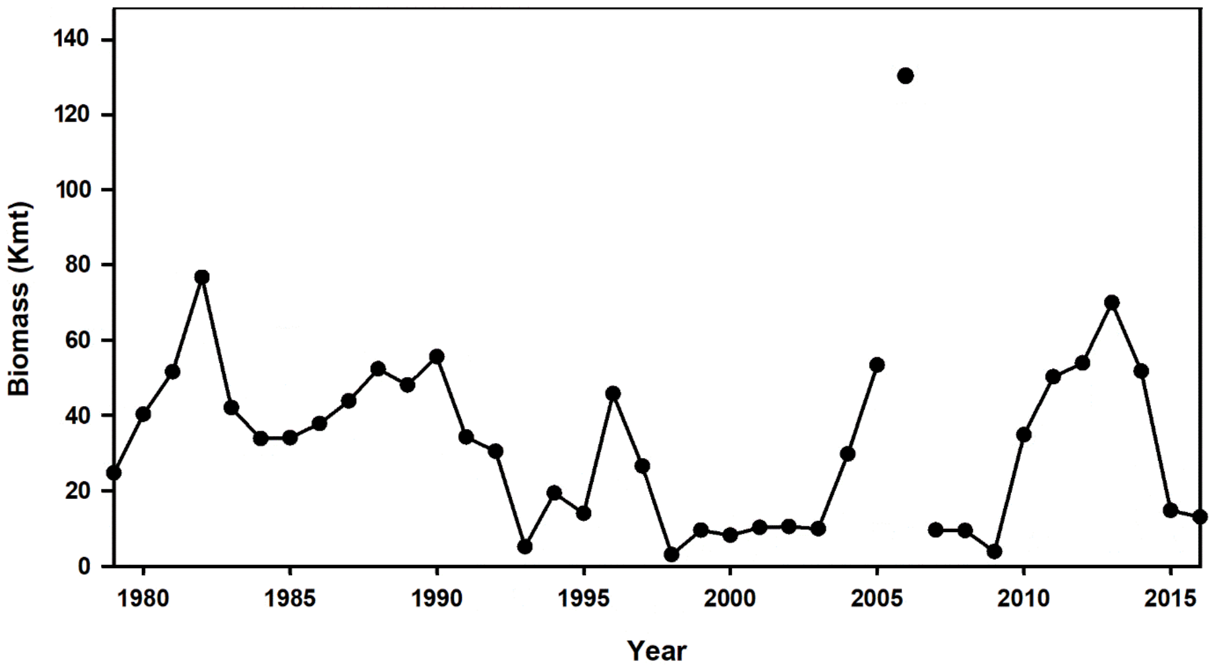


Figure E-1. Herring SSB in thousand metric tons (Kmt) for the San Francisco Bay estimated from egg deposition surveys, summed from December to March each year. Note: These values are from a truncated season so are lower than those in the published Department report because they do not include some spawning which occurs earlier or later in the season. Anomalously high SSB in 2006 is indicated by the break in the time series; the 2006 value was identified as an outlier and excluded from the regression analysis for forecasting purposes. Figure modified from Sydeman and others (2018).

Based on a recognized biological shift in the ecosystem around 1990 (Hare and Mantua, 2000), relationships between potential indicators (Table E-1) and Herring SSB were explored for both the full time series (1979 to 2016) and the more recent period (1991 to 2016). We applied Spearman rank correlations to initially examine pair-wise relationships (Table E-2). Correlation analysis computes a correlation coefficient (denoted as the Greek letter "rho" (ρ)) that describes the linear relationship between two variables. This metric describes how much one variable tends to change when the other variable changes. The value of ρ can range from -1 to +1, and magnitude of ρ quantifies how much the two variables appear to be related. For example, in cases where both variables increase or both decrease (a positive correlation), the magnitude of ρ will be higher (closer to +1). In cases where one increases while the other decreases (a negative correlation), the magnitude of ρ will be lower (closer to -1). A correlation between two variables was considered statistically significant when $p < 0.05$.

Because it takes two to three years for Herring to mature, time lags from one to three years were incorporated into these analyses (Figure E-2). All but one environmental variable produced non-significant correlations during the full time period, most likely due to changing variability through the SSB time series.

There were many more significant relationships for the later period. The highest correlations were found between SSB_{yr-1} and SSB ($r^2 = 0.41$, $p < 0.005$) and between Young of the Year $(YOY)_{yr-3}$ and SSB ($r^2 = 0.57$, $p < 0.005$).

Table E-1. Ecosystem variables, including those tested in the model but not selected and those not used because they were redundant or had insufficient data[2] (Sydeman and others, 2018) (Supplement 1, in Table SM1, SM2).

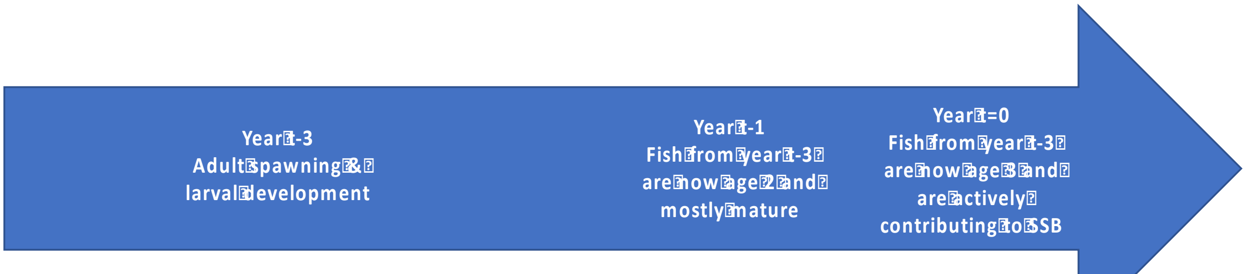
Data	Label	Period	Location	Units	Temporal resolution	Source
Ecosystem						
Herring SSB	SSB	1980–2016	San Francisco Bay	Thousand metric tons (Kmt)	Seasonal sum across months	Department Herring Management Program
Midwater trawl Catch Per Unit Effort (CPUE) of age-0 Herring	YOY	1980–2015	San Francisco Bay	Number of fish standardized by effort	Seasonal average over several months	Department San Francisco Bay Study/Interagency Ecological Program for San Francisco Estuary
Midwater trawl CPUE Age-1, and Age-2+[1]	Age-1, Age-2+	1980–2015	San Francisco Bay	Number of fish per effort	Seasonal average over several months	Department San Francisco Bay Study/Interagency Ecological Program for San Francisco Estuary
Herring condition index[1]	HCI	1984–2015	San Francisco Bay	g/cm^3	Seasonal average across months	Department Herring Management Program
Herring age structure[2]	HAS	1983-2015	San Francisco Bay	% biomass	Annual	Department Herring Management Program
Seabird productivity[1a]	SBP	1980-2014	Farallon Islands	Repro-ductive success	Annual	US Fish and Wildlife Service/Point Blue Conservation Science
Environmental						
Midwater trawls temperature and salinity[1]	Trawl T Trawl S	1980–2016	35 stations throughout San Francisco Bay	°C, PSU	3-month average	Department San Francisco Bay Study/Interagency Ecological Program for San Francisco Estuary
Sacramento River Delta Outflow[1b]	Outflow	1996–2016	San Francisco Bay	Acre-ft	3-month average	California Department of Water Resources

Buoy N26 sea surface temperature	SST	1982–2015	37.8°N, 122.8°W	°C	3-month average	NOAA National Data Buoy Center
Farallon Islands sea surface salinity[1]	Far-SSS	1979–2015	Gulf of the Farallones	PSU	3-month average	Point Blue Conservation Science, Shore Station Program
Bakun Upwelling Index[1c]	BUI	1979–2015	39°N	m^3/s/ 100m	3-month average	Pacific Fisheries Environmental Laboratory/ NOAA
Multivariate El Niño Southern Oscillation Index[1d]	MEI	1979–2015	Tropical Pacific	No units	3-month average	Earth System Research Laboratory/NOAA
Pacific Decadal Oscillation[1e]	PDO	1979–2015	North Pacific	No units	3-month average	Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
North Pacific Gyre Oscillation[1f]	NPGO	1979–2015	North Pacific	No units	3-month average	E. Di Lorenzo
Multivariate Ocean Climate Indicator[1g]	MOCI	1979–2015	Central California (34.5-38°N)	No units	Seasonal	Farallon Institute

Note: [a]Krill-eating seabirds Common Murre, *Uria aalge*, Western Gull, *Larus occidentalis*, and Cassin's Auklet, *Ptychoramphus aleuticus*, were chosen to provide an indicator of forage conditions for Herring, which also consume krill.
[b]When considering influences on Herring, including outflow and precipitation, outflow was tested since it serves as a proxy for salinity and precipitation.
[c]The Bakun upwelling index is an indicator of the wind forcing on the coastal ocean; it can also serve as a proxy for Ekman transport.
[d]The MEI synthesizes six observed variables (sea level pressure, meridional and zonal wind, air and sea surface temperature, and total cloudiness) over the tropical Pacific to monitor ENSO.
[e]The PDO is a water surface temperature pattern in the North Pacific, defined as the leading principal component of SST variability from 20 to 90°N.
[f]The NPGO is a climate pattern in the North Pacific defined as the second dominant mode of sea surface height variability, related to water circulation around the basin.
[g]MOCI is a synthesized indicator of regional and local ocean and atmospheric conditions in central California (34.5 to 38°N). This indicator includes the variables: BUI, sea level, along shore wind stress, SST and sea level atmospheric pressure from NDBC buoys, MEI, PDO, NPGO, and the Northern Oscillation Index (García-Reyes and Sydeman, 2017).

Table E-2: Spearman rank correlation (ρ) between SSB and potential indicators of SSB. Lag, in years, and months if applicable, are shown in parentheses. Only nominally significant correlations ($p < 0.05$) are shown. Correlations were performed for the periods 1979–2016 and 1991–2016 due to increased variance in the latter period (Sydeman and others, 2018).

Biological Data	1979-2015	1991-2015
Standing Stock Biomass	ρ=0.65 (yr-1)	ρ=0.51 (yr-1)
CPUE Age-0 abundance	ρ=0.55 (yr-2, ρ=0.64 (yr-3)	ρ=0.57 (yr-2), ρ=0.70 (yr-3)
CPUE Age-1 abundance	ρ=0.35 (yr-3)	ρ=0.42 (yr-3)
CPUE Age-2+ abundance	-	ρ = 0.42 yr-3)
Herring condition index	-	-
Seabird productivity	-	-
Environmental Data	1979-2016	1991-2016
Midwater trawls temperature	-	-
Buoy N26 sea surface temperature	-	ρ=-0.41 (May-Jul, yr-3)
Midwater trawls salinity	-	ρ=0.48 (Aug-Oct, yr-3)
Farallon Islands sea surface salinity	-	-
Sacramento River Delta Outflow	-	ρ=-0.59 (Jul-Sep, yr-3)
Bakun Upwelling Index	ρ=-0.41 (Oct-Dec, yr-3)	-
Multivariate El Niño Southern Oscillation Index	-	-
Pacific Decadal Oscillation	-	ρ = -0.46 (Apr-Jun, yr-3)
North Pacific Gyre Oscillation	-	ρ = 0.45 (Jul-Sep, yr-2, yr-3)
Multivariate Ocean Climate Indicator	-	ρ = -0.46 (Jul-Sep, yr-3)



Timeline	2015	2016	Early 2017	Late 2017	2018
Measured/ Predicted value	YOY abundance		SSB	Offshore Temperature	SSB
Time Frame	April-October		December-March	July-September	December-March
Modeled Year	Year t-3		Year t-1	Year t-1	Year t=0

Figure E-2. Timeline of Herring maturation with example of time lags based on data from 2015 to 2017 for predictions for 2018.

Next, a stepwise multivariate regression model was used to understand which variables could together provide the best explanation of observed patterns in Herring SSB. Regression analysis is another technique used to help understand the relationship between two variables. However, while correlation analysis uses rankings to define the relationship between variables, regression analysis uses a line. When the relationship between the two variables is significant ($p < 0.05$), it is possible to use the equation of the line to make predictions about values that might be of interest. Variables on the x-axis are called "independent variables", while variables on the y-axis are called "dependent variables" because they change depending on x-axis values. Regression analysis computes a regression coefficient (denoted as r^2) that describes the relationship between variables: the higher the value of r^2, the more related the two variables are. In the case of multiple regression, the linear relationship is tested between multiple independent variables (for example, SST and YOY abundance) and the same dependent variable (SSB in this study). The goal of including more independent variables is to improve predictions of the dependent variable. The goal of the Farallon Institute was to develop a model with the following characteristics:

- parameters that explained the most variability (in other words, the highest and most significant r^2 values),
- low predictive error values (an indicator of reliability),
- the lowest AIC values (an estimation of the quality of the model relative to other possible models),
- and utilized monitoring data readily available to managers in an appropriate timeframe for setting fishing quotas.

Based on these criteria, the three-factor models out-performed simpler one- and two-factor models by a large margin (improved $r^2 = 0.64$-0.67 compared to 0.31 to 0.58; improved model fit AIC = 188 to 190 compared to 193 to 204, and reduced predictive error of 63% to 69% compared to 77% to 119%) (Sydeman and others, 2018) (Table E-3). The three-factor model that provided the best prediction for the current year SSB included: SSB_{yr-1}, YOY_{yr-3} and $SST_{(Jul-Sep)\ yr-1}$. Notably, current Department fishing quotas are based on SSB_{yr-1}.This finding strongly supports the inclusion of YOY data in particular as well as SST data in estimation of SSB, and highlights how incorporating additional information can result in more accurate forecasts of SSB.

Table E-3. Multivariate regression models and statistics for the period 1991 to 2016. F-statistics, p-values, adjusted r^2 and AIC values are given by forward and backward stepwise regression. Predictive error is the averaged prediction errors from the cross-validation method (Sydeman and others, 2018). Lag in years for each term indicated in parentheses. SST consists of the 3-month average from July to September prior to the season in question.

Term	Coefficient	t-stat	p-value
SSB ~ SSB_{yr-1} $F_{1,22} = 11.3$, p-value < 0.01, Adjusted $R^2 = 0.31$, AIC = 204, Predictive Error = 119%			
SSB_{yr-1}	0.57	3.36	< 0.005
SSB ~ YOY_{yr-3} $F_{1,23} = 31.1$, p-value < 0.0001, Adjusted $R^2 = 0.56$, AIC = 201, Predictive Error = 77%			
YOY_{yr-3}	0.025	6.42	< 0.0001
SSB ~ SSB_{yr-1} + YOY_{yr-3} $F_{2,21} = 16.6$, p-value < 0.0001, Adjusted $R^2 = 0.58$, AIC = 193, Predictive Error = 81%			
SSB_{yr-1}	0.25	1.58	0.13
YOY_{yr-3}	0.02	3.85	< 0.001
SSB ~ SSB_{yr-1} + YOY_{yr-3} + $SST_{(Jul-Sep)\ yr-1}$ $F_{3,20} = 15.9$, p-value < 0.0001, Adjusted $R^2 = 0.66$, AIC = 189, Predictive Error = 69%			
SSB_{yr-1}	0.28	1.97	0.06
YOY_{yr-3}	0.019	4.06	< 0.005
$SST_{(Jul-Sep)\ yr-1}$	-7.26	-2.49	< 0.05

The use of a validation procedure is recommended to establish guidelines for model estimates to remain within certain bounds. For model validation, each year the Department should compare forecast SSB from the model with observed/measured SSB from egg deposition surveys. If the model prediction skill deviates from the mean value (in other words, the estimate is within about 69% of the predicted value) in one year, no management response is necessary. If skill deviates by more than 69% for two sequential years, it is recommended that the Department consider this a warning. If it deviates for more than two sequential years this may indicate a potential problem, and the model should be checked for continuing veracity. The model prediction skill should also not stay consistently above or below the mean. Regardless of annual model prediction skill, it is also recommended that every five years the Department test for continuing significance of predictor variables (in other words, the independent variables) in the forecasting model. If terms lose significance or model prediction skill decreases significantly, the Department should consider revision of the forecasting model.

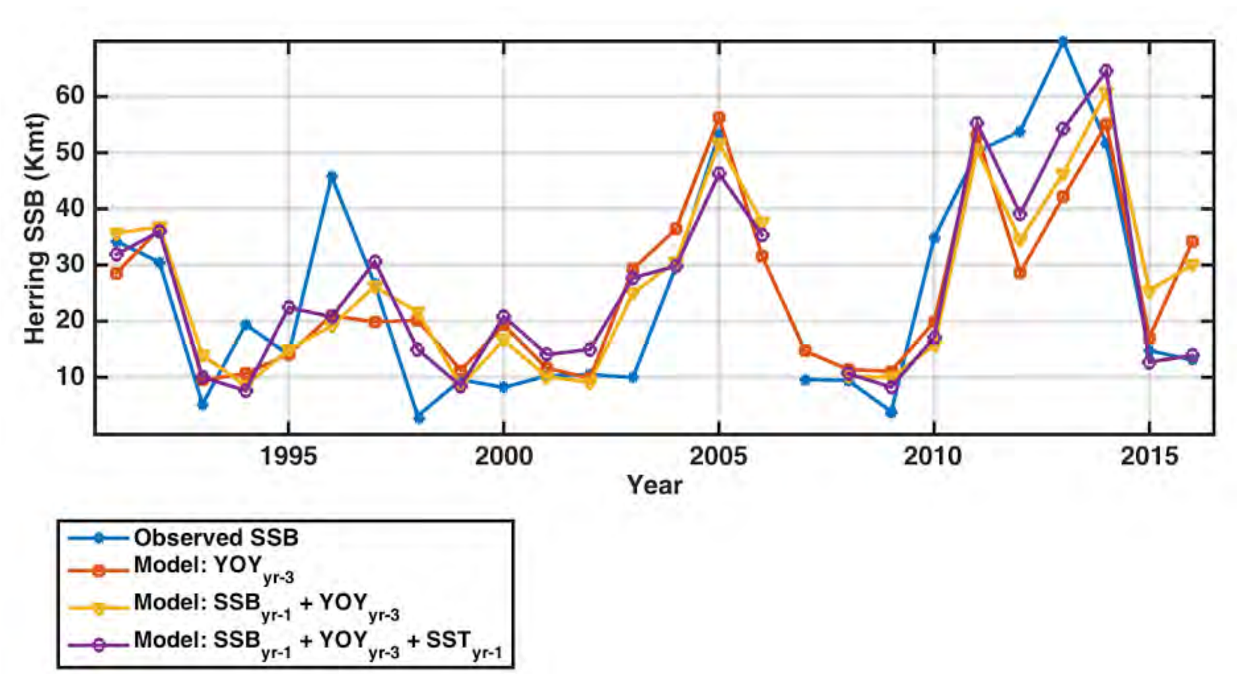


Figure E-3. Observed and modeled San Francisco Bay Herring SSB time series for 1991 to 2016. Note: There is no observation for 2006 since it was identified as an outlier during analysis. Observed biomass is shown in blue and other colors indicate the different models for biomass that include the terms YOYyr-3, SSByr-1, and SST(Jul-Sep) yr-1. Figure modified from Sydeman and others (2018).

Calculating future estimates of SSB

This section describes an approach that can be followed each year using readily available information to provide improved estimates for SSB. The data used for analysis are available by the end of September each year, which allows one month to calculate estimates prior to the start of the commercial Herring fishing season in November.

The equation for prediction of current year SSB is as follows:

Equation 1: SSB (in Kmt) = SSB_{yr-1} (sum: December through March) + YOY_{yr-3} (mean: April through October) + SST_{yr-1} (mean: July through September)

Therefore, estimation of SSB (2018) requires: SSB (2017, summed December through March), YOY (2015, average of individually-summed months for April through October), and SST (2017, average of July through September).

SSB_{yr-1} is based on spawning egg deposition only and can be acquired from the Department. This value is typically reported during the summer. The model uses the sum of biomass across San Francisco Bay for December to March, which can be derived from the annual Department report table. If additional spawning occurs outside this date range, e.g., in November or April, it would need to be excluded. Department reports Herring SSB in short tons, which needs to be converted to thousand metric tons for use in Equation 1:

Equation 2: 1 short ton = 0.907184 metric tons

Therefore, SSB_{2017} was 18,313 short tons, or 16.613 thousand metric tons. YOY abundance data are available from a spreadsheet maintained by the Department (Kathy Hieb, pers. comm.). The Department collects abundance data on pelagic fish using mid-water trawls throughout the San Francisco Bay at monthly intervals at 52 stations; this analysis is based on the original 35 stations that have been standardly sampled since 1980 including those focused on the central San Francisco Bay region where Herring are common. To summarize YOY_{yr-3} abundance, calculate the mean CPUE for three years prior. First select the appropriate stations using only Series = 1 (representing the original 35 stations), and calculate CPUE for each station:

Equation 3: CPUE = (PACHERAge0/ tow volume) * 10,000

Where PACHERAge0 represents the number of age-0 Herring caught in each net tow, and is used in combination with tow volume data presented in the Department spreadsheet. Next sum the CPUE data for each month based on survey numbers four to ten, representing months April through October. Finally, average the summed monthly data. For calculations of SSB_{2018}, mean CPUE from 2015 is used, which based on survey months April to October was 36.1.

SST data comes from offshore buoy N26 at station 46026 provided by the National Data Buoy Center (NDBC) and the National Oceanic Atmospheric Administration (NOAA). Data for each month from the current year (July through September) can be downloaded (http://www.ndbc.noaa.gov/station_history.php?station=46026) and located in the column labeled WTMP. Data should be averaged for each month, then subtract the mean temperature from each month (based on years 1985-2015: July = 13.16 C˚, August = 13.97 C˚, September = 14.24 C˚) to calculate the temperature anomaly for each month. Finally, average the anomaly across the three months (July through September). For 2017, the average $SST_{(Jul-Sep)yr-1}$ was 14.1 C˚, and the anomaly was 0.2923.

Lastly, apply the forecasting model:

Equation 4: SSB_{2018} (Kmt) = (SSB_{2017} (Kmt) * 0.2803) + (YOY_{2015} * 0.019026) + ($SST_{(Jul-Sep)\ 2017}$ * -7.2582) + 4.092

SSB_{2018} = (16.613 * 0.2803) + (36.1 * 0.019026) + (0.2923 * -7.2582) + 4.092 = 7.98 Kmt

Full model results from Equation 4 for 2018 SSB are presented in Table E-4.

Table E-4. Full model results for the forecasting model selected

$SSB \sim SSB_{yr-1} + YOY_{yr-3} + SST_{(Jul\text{-}Sep)\ yr-1}$
$F_{3,20}$ = 15.9, p-value < 0.0001, Adjusted R^2 = 0.66, AIC = 189, Predictive Error = 69%

Term	Coefficient	t-statistic	p-value
SSB_{yr-1}	0.28	1.97	0.06
YOY_{yr-3}	0.019	4.06	< 0.005
SST_{yr-1}	-7.26	-2.49	< 0.05

Model validation should be conducted every year to verify model prediction skill, and every five years to verify that the relationships between SSB, YOY abundance, and SST are maintained. To validate that the modeled SSB is still performing within the range of deviation described by the regression equation (69%), comparison of predicted and observed SSB estimates is required. For the 2018 example, calculate the percent error based on 2017 predicted and observed SSB values:

Equation 5: Percent Deviation = ((Observed SSB – Predicted SSB)/Observed SSB)*100

Based on 2017 values for observed (16,613 mt) and predicted (15,113 mt): Percent $Deviation_{2017}$ = ((16,613-15,113) / 16,613) * 100 = 9%. Therefore, the model is performing within the expected range of error (in other words, <69%). If the percent deviation exceeds the mean, pay attention: deviation in one year is acceptable; if high deviation in two sequential years is observed this should be interpreted as a warning, and if for three sequential years, the model prediction skill has likely broken down. The next step would be to re-test the relationships between SSB, YOY abundance, and SST (see main text for more detail on testing the significance of the predictor variables every five years).

Appendix F Summary of Data on Trophic Interactions and Potential Forage Indicators for Pacific Herring in San Francisco Bay

During development of the Pacific Herring (Herring), *Clupea pallasi,* Fishery Management Plan (FMP), the Farallon Institute was contracted by the Steering Committee, a group of stakeholders representing industry and conservation groups and Department of Fish and Wildlife (Department) staff, to conduct a study on the trophic interactions affecting the Herring stock in San Francisco Bay, as well as recommend a suite of environmental indictors that could be used to assess regional forage conditions each year when setting quotas. This information on predator-prey dynamics in the San Francisco Bay region was used to develop a decision tree to incorporate ecosystem considerations into yearly quota decision making. This document summarizes the information produced by the Farallon Institute in fulfillment of their contract, describes a decision tree developed from this information to assist Department staff in considering forage conditions when setting quotas each year. Additionally, a retrospective analysis of the decision tree's potential performance is presented and discussed.

Predators of Pacific Herring

Data from a total of 83 predators known to eat Herring (58 species) or Herring roe (33 species, including eight that also eat fish), were summarized to assess the occurrence of Herring in predator diets within the California Current Ecosystem (CCE) (Table F-1), which is an eastern boundary current upwelling system off the West Coast of the United States.

Adult Herring can compose up to 30% of Pacific Cod, *Gadus macrocephalus*, diet, and 51% of Chinook Salmon, *Oncorhynchus tshawytscha*, diet in the CCE, with feeding occurring mostly during winter months. Northern Fur Seal diet samples in California studies contained no Herring presumably because the offshore distribution of Northern Fur Seal range in California does not overlap with nearshore Herring (Perez and Bigg, 1986). San Francisco Bay is near the southern limit of Herring's range and Herring are less prominent in predator diets there than in the northern CCE (Szoboszlai and others, in revision).

Table F-2. Known predators (83) of adult Herring and Herring roe from the CCE (Szoboszlai and others, 2015): bold indicates duplication for 8 species.			
A) Summer (April-September) studies of predator diets (does not overlap winter diet during Herring spawning migrations).			
Spiny Dogfish	29%	Jack Mackerel	2%
Humpback Whale	13%	Fin Whale	2%
Pacific Hake adults	11%	Harbor Porpoise	2%
Black Rockfish	10%	Sperm Whale	2%
Chinook Salmon	9%	Marbled Murrelet	2%
Coho Salmon	9%	Pacific Hake juveniles	1%
Caspian Tern	7%	Sablefish	1%
Common Murre	7%	Least Tern	<1%
Northern Fur Seal	7%	Cassin's Auklet	<1%
Rhinoceros Auklet	6%	Sooty Shearwater	<1%
Harbor Seal	5%	L-B Common Dolphin	<1%
California Sea Lion (Zalophus californianus)	4%	S-B Common Dolphin	<1%
Double-Crested Cormorant	2%		
B) Predators of adult Herring not assessed in Szoboszlai and others (in revision) study.		C) Spawn-eating predators (Bayer, 1980; Weathers and Kelly, 2007).	
Ancient Murrelet	Lingcod	American Coot	Lesser Scaup
Arctic Loon	Mew Gull	American Widgeon	Long-Tailed Duck
Arrowtooth Flounder	Orca Whale	Barrow's Goldeneye	Mallard
Bat Ray	Pacific Cod	Black Brant	Mew Gull
Blue Shark	Pacific White-Sided Dolphin	Black Scoter	Northern Pintail
Bonaparte's Gull	Pelagic Cormorant	Bonaparte's Gull	Pelagic Cormorant
Brandt's Cormorant	Pigeon Guillemot	Brandt's Cormorant	Red-Breasted Merganser
California Gull	Red-Breasted Merganser	Bufflehead	Redhead
Chum Salmon	Sei Whale	Canvasback	Ring-Billed Gull
Common Merganser	Shortspine Thornyhead	Common Goldeneye	Ruddy Duck
Copper Rockfish	Soupfin Shark	Common Loon	Surf Scoter
Cutthroat Trout	Steller Sea Lion	Eurasian Wigeon	Western Grebe
Dall's Porpoise	Western Grebe	Glaucous-Winged Gull	Western Gull
Glaucous-Winged Gull	Western Gull	Greater Scaup	White-Fronted Goose
Gray Smoothhound	Yelloweye Rockfish	Harlequin Duck	White-Winged Scoter
Gray Whale	Yellowtail Rockfish	Hooded Merganser	
Jumbo Squid		Horned Grebe	

Herring Predation in California

In order to understand the impact of the San Francisco Bay Herring fishery on predators, it is important to focus on studies that overlap temporally and spatially with the San Francisco Bay Herring population (Table F-2). There are limited data from central California, particularly during winter when Herring gather in dense schools near to and inside San Francisco Bay and are likely to be most important to predators (Szoboszlai and others, in revision; Szoboszlai and others, 2015). The winter data for central California suggest the potential for strong seasonal dependencies. The best winter predator diet data on Herring exists for Chinook Salmon in the Gulf of the Farallones (GOF), just outside San Francisco Bay (Table F-2).

Herring were dominant in the diet of salmon collected from coastal Herring holding areas during winter (Merkel, 1957). Herring totaled 13% of salmon diet (by mass) based on the average of ten months during one year (Merkel, 1957). However, the amount of Herring observed in the salmon diet was higher in the winter, with salmon consuming ~50% Herring in February and March (Merkel, 1957). Herring in winter salmon diet peaked at roughly 20% in a similar study in the early 1980s (Thayer and others, 2014). High feeding rates during prey pulses, and the subsequent increase in growth may be one way juvenile salmon increase survival through early marine phases (Litz and others, 2018).

Table F-2. Herring in predator diets in California, with focus on localized data in time and space surrounding Herring spawning in San Francisco Bay (SFB). The GOF is just outside SFB. Monterey Bay (MB) is south of the GOF. Herring spawn in winter months peaking from December to March. For GOF diet, percentage of Herring in the diet is indicated by an average value with range in parentheses if data from more than one study was available. The range is important because averaging dampens extremes and does not reflect importance to predators during prey pulses. Months of available diet were provided in the source column unless diet data was collected in all seasons. Light gray shading denotes related winter data for California; dark gray shading denotes predators for which higher Herring consumption in California appears to occur in the non-winter months.

Herring predator	Diet from California	Winter diet central CA	CCS summer diet[1]	Summer California diet	Winter California diet	GOF (Sep-Dec) diet	GOF (Oct-Mar) diet	GOF-MB (Dec-Mar) diet	GOF (Feb-Mar) diet	GOF (Mar-Apr) diet	Source - Winter diet central California (years)
Chinook Salmon	x	x	9%	4%	27%	3% (1-5%)	16% (5-27%)	29% (10-49%)	29% (10-49%)	24% (9-39%)	1955 GOF (Merkel, 1957); 1980-86 GOF (Thayer and others, 2014)
Humpback Whale	x	x	~13%	x[3]	~19%	~5%		~33% (26-40%)			1920, 1922 Dec-Mar MB (Clapham and others, 1997); 1988, 1990 Sep-Dec GOF (Kieckhefer, 1992)
Common Murre	x	x	7%	0%	6%		20% (12-28%)			28%	1974-75 Sep-Apr MB (Baltz and Morejohn, 1977); 1985-88 coastal GOF only[2] (Ainley and others, 1996)
Harbor Seal	x	x	6%	8%	1%						1968-1973 cen CA (Jones, 1981); 1991-2 SFB, MB, Elkhorn Slough (Oxman, 1995; Torok, 1994; Trumble, 1995); 2007-8 SFB (Gibble, 2011)
Pacific Hake	x		11%	7%							1989 (Jul-Sep) Pt Conception. - Cape Blanco (Buckley and others, 1999)
Rhinoceros Auklet	x	x	6%	1%	1%						1974-75 Sep-Apr MB (Baltz and Morejohn, 1977)
California Sea Lion	x	x	4%	1%	1%						1998-9 Feb-Apr MB (Weise and Harvey, 2008); 2009 Nov-Dec MB (Robinson and others, 2018)

[1]Data from Szoboszlai and others (in revision).

[2]Outer continental shelf diet samples did not contain the level of Herring that coastal samples did, so coastal samples were used for GOF maximums.

[3] Some data on humpback summer diet in California was available from the early 1920s but was not summarized, as levels of Herring were lower than in winter, which was summarized.

Regional Forage for Herring Predators

While there are limited data available with which to assess the extent to which predators utilize the San Francisco Bay Herring resource, it is possible to glean insight into what other forage species are eaten by predators of Herring. Based on the available data, regional forage species also consumed by predators of Herring in central California primarily include other small pelagic fishes (Pacific Sardine, *Sardinops sagax*, and Northern Anchovy, *Engraulis mordax*); invertebrates including krill (Euphausiidae) and Market Squid, *Doryteuthis opalescens*; juvenile rockfish, *Sebastes* spp.; and to a lesser extent juvenile groundfish (Pacific Hake, *Merluccius productus*, and sanddabs, *Citharicthys* spp.). Some of these species are consumed year-round, while other species are more important in winter, when Herring are concentrated for spawning and more available as prey. However, given the limited number of studies, specifically those that overlap spatially and temporally with the San Francisco Bay population of Herring, more information is needed to understand the relative importance and suitability of other regional forage species to predators (particularly during winter months). Therefore, caution is necessary for adjusting management measures based on forage indicators.

Regional Forage Availability

Considering regional forage dynamics provides a view of overall ecosystem condition with regard to mid- and upper-trophic level predator diet requirements. Understanding the status of other forage species within the region, and particularly when the abundance of these species is low, can indicate when there is a potential for increased predation on Herring. The Catch Per Unit Effort (CPUE) of regional forage (Northern Anchovy, Pacific Sardine, krill, Market Squid, juvenile rockfish, juvenile sanddabs, and juvenile Pacific Hake) in the central CCE (defined as the nearshore region of the eastern Pacific between Crescent City Harbor and Point Conception) is measured annually using National Oceanic and Atmospheric Administration (NOAA) fisheries-independent trawl surveys in spring/summer (Sakuma, 2017). These data are publicly available at the NOAA California Current Integrated Ecosystem Assessment (CCIEA) website, and summarized to describe an index of the availability relative to the long-term mean (defined as the mean of each index from 1990 to 2017, the most recent year of available data) and upper and lower standard deviations. The Department can use these indices to determine when the status of each of these regional forage species is unusually low or unusually high (as defined in Table F-3) relative to the last 30 years. This index can be produced by National Marine Fisheries Service (NMFS) staff as early as August or September each year (C. Harvey pers. comm.; J. Field pers. comm.) for use in the San Francisco Bay fishery quota setting procedure.

An analysis of correlations between the regional forage indicators and environmental conditions between 1990 and 2012 found that a significant amount of the variation seen in these forage indicators could be attributed to a complex set of regional and basin-scale variables such as temperature, salinity, upwelling, and sea-level, which is a proxy for the magnitude and direction of water transport in the CCE (Ralston and others, 2015). During years that are characterized by colder water, higher salinity, early and strong upwelling, and high transport, the central CCE forage assemblage is dominated by increased numbers of Young of the Year (YOY) groundfish, krill, and Market Squid, likely due to higher survival of juveniles in these high nutrient conditions (Ralston and others, 2015; Santora and others, 2017). In years that are characterized by warmer water, lower salinity, delayed upwelling, and low transport, the central CCE region experiences reduced numbers of those species and greater representation of coastal pelagic species, such as sardine and anchovy (Ralston and others, 2015; Santora and others, 2017). This suggests that, under normal ecosystem function, the central CCE fluctuates between “cold water” and “warm water” assemblages, and similar patterns can be seen in Table F-3.

Table F-3. Historical status of prey species within the central CCE from NOAA's annual rockfish trawl surveys. The status was classified as "High" (in green) if the index for that year was >1 standard deviation (s.d.) above the long term mean (defined as the mean index between 1990 and 2017), "Moderate" (in yellow) if the index was within ∓1 s.d.) of the long-term mean, and "Low" (in red) if the index was >1 s.d. below the long-term mean. For Pacific Sardine and Northern Anchovy, in which the wide s.d. resulted in negative values for 1 s.d. below the long-term mean, the status was classified as "Low" if the index was >50% of the long term mean. Data were accessed on 08 November 2018 at https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-indicator-status-trends.

	Regional Prey Indices						
Year - Fall	Pacific Sardine	Northern Anchovy	Pacific Hake	Rockfish	Sanddab	Market Squid	Krill
1990	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
1991	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate
1992	Low	Moderate	Moderate	Moderate	Moderate	High	Low
1993	Low	Moderate	High	Moderate	Moderate	Moderate	Moderate
1994	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
1995	High	Moderate	Low	Moderate	Moderate	Moderate	Moderate
1996	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low
1997	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
1998	High	Moderate	Low	Low	Low	Low	Low
1999	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
2000	Moderate	Low	Moderate	Moderate	Moderate	Moderate	Moderate
2001	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
2002	Low	Low	Moderate	Moderate	High	Moderate	Moderate
2003	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate
2004	Moderate	Moderate	High	Moderate	Moderate	Moderate	Moderate
2005	High	High	Low	Low	Low	Moderate	Moderate
2006	High	High	Low	Low	Low	Low	Moderate
2007	High	Moderate	Low	Low	Low	Low	Moderate
2008	High	Low	Moderate	Moderate	Low	Low	High
2009	Moderate	Low	Moderate	Moderate	Moderate	Moderate	Moderate
2010	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate
2011	Low	Low	Moderate	Moderate	Moderate	Moderate	High
2012	Low	Low	Moderate	Moderate	Moderate	High	High
2013	Low	Low	Moderate	High	High	High	High
2014	Low	Low	Moderate	High	High	High	High
2015	Low	Low	High	High	High	High	Moderate
2016	Low	Low	High	High	Moderate	Moderate	Moderate
2017	Low	Low	Moderate	Moderate	Moderate	High	High

While the complex interplay of variables makes it difficult to predict exactly how predators will respond to changing forage assemblages in a given year, the available data suggest that many top predators are able to switch between warm and cold water forage assemblages as necessary. For example, a study of Humpback Whale diets over a 20-year period in the CCE found that diets were dominated by krill during periods characterized by cool sea surface temperature (SST), strong upwelling and high krill biomass, and dominated by Northern Anchovy and Pacific Sardine when the SST was warmer and seasonal upwelling was delayed (Fleming and others, 2016). Breeding colonies of Common Murres in the GOF feed primarily on YOY rockfish when they are abundant and switch to target Northern Anchovy when YOY rockfish are unavailable (Ainley and Boekelheide, 1990; Sydeman and others, 2001). California Sea Lion diet composition data collected in Monterey Bay between 1997 and 1999 showed that Pacific Sardines, which had high abundances in the central CCE at that time, made up 47.3% of sea lions' diet by mass, while rockfish were the second most important prey species (28.6%) (Weise and Harvey, 2008). This suggests that these alternating forage assemblages may play the same functional role (mid-trophic level forage) in the CCE, and that shifts between these two assemblages represent natural fluctuations. However, while Northern Anchovy and Pacific Sardine are considered "high energy" forage and krill (Figure F-1), YOY groundfish, and Market Squid are considered "medium energy" (Figure F-1), Common Murre colonies have been found to have lower rates of breeding success when the forage assemblage is dominated by coastal pelagic species (Field and others, 2010; Wells and others, 2017). More information is needed to understand the relative importance of forage species to various predators, and caution should be applied when adjusting management measures based on forage indicators.

Climate change may further complicate attempts to predict how forage indices will fluctuate in response to environmental changes. Between late 2013 and early 2016 an anomalous warm water event, termed the North Pacific Marine Heatwave (NPMH), occurred, resulting in delayed upwelling, warmer waters, and lower productivity in the region (Gentemann and others, 2017). During this period YOY groundfish, krill, and Market Squid relative availability remained moderate to unusually high while sardine and anchovy remained low (Figure F-1). Meanwhile, krill abundance declined sharply in 2015, following an unusually stable trend of high abundance in preceding years (Figure F-1). In 2016 oceanic conditions in the northeastern Pacific began to return to normal, but this unusual response of prey species to the NPMH highlights the fact that more information is needed on how forage indices respond to environmental changes.

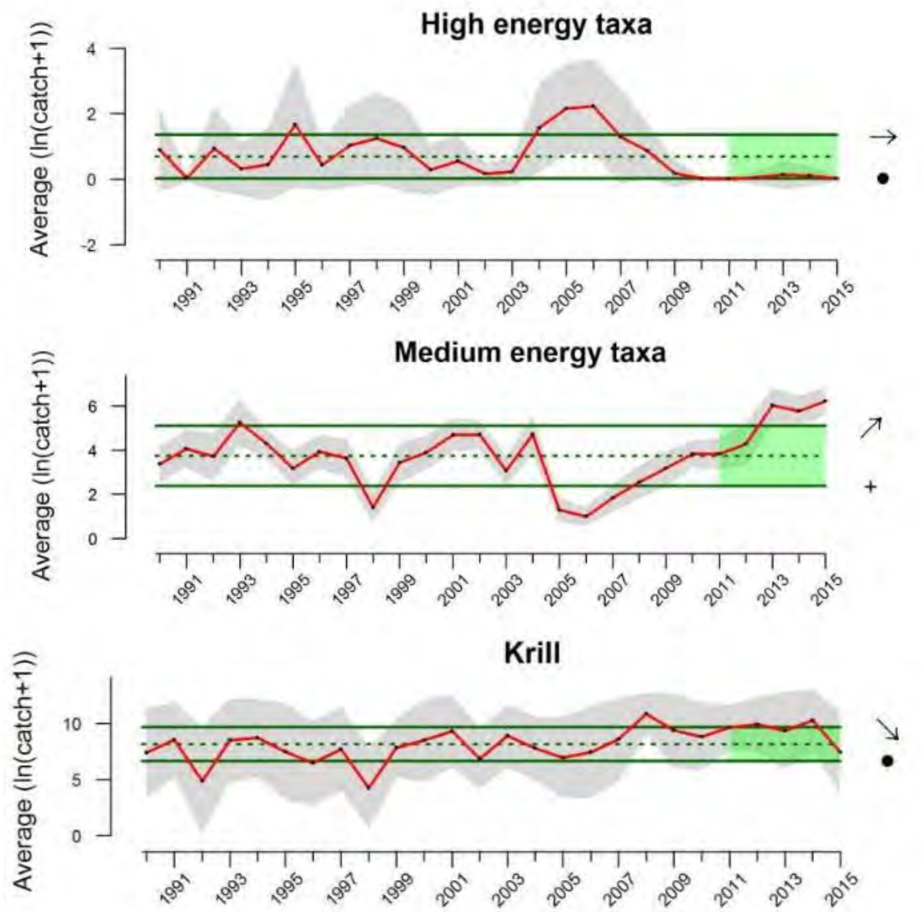


Figure F-1. Geometric mean CPUEs (#/haul) of key forage groups in the central CCE. High energy taxa includes sardine and anchovy, while medium energy taxa includes Market Squid and YOY groundfish. Horizontal lines show the mean (dashed line) ± 1.0 s.d. (solid lines) of the full time series. Arrows at upper right indicates whether data over the last five years (green shaded areas) had a positive trend, a negative trend, or no trend. Symbols at lower right indicates whether the mean over the past five years was greater than (+), less than (–), or within 1 s.d. (•) of the mean of the full time series (Reproduced from Harvey and others (2017)).

The information presented in Table F-3 represents a first step towards understanding the relative forage availability within the central CCE in a given year. While these indices are designed to indicate only whether the status in each year is high or low relative to the observed time series, the patterns that have emerged (Ralston and others, 2015) suggest that, while fluctuations between the high productivity and low productivity assemblages are natural, low levels in both forage assemblages simultaneously might indicate a regional decline in forage availability, and such a decline might indicate a need for additional management response. There are a number of limitations that suggest that these data should be interpreted cautiously. Because the time series begins in 1990, "high" and "low" are only defined relative to this period. Additionally, given the paucity of studies in the central CCE on Herring predation, it is difficult to know whether the indices in Table F-3 actually represent alternative forage for Herring predators. The data for these indicators are collected in trawl surveys conducted farther offshore than Herring are believed to occur, and Herring do not show up in the surveys in notable amounts. As such, they may provide a snapshot of offshore, rather than nearshore, forage availability. However, they represent the best available data at this time, and there is some evidence linking Herring predators to these species.

Indicators on Predator Population Health

The main predator species in central California for which diet data on Herring exist are Chinook Salmon, Common Murre, Humpback Whale, Harbor Seal, Pacific Hake, and Rhinoceros Auklet (Table F-2). Sources of time series for these predators, including population size, reproductive success, and survival were assessed to determine their availability and suitability for use as indicators of predator population health (Table F-4).

For many species of marine wildlife (e.g., marine mammals, seabirds, and large fish), population size may not respond immediately to reduced prey availability due to delayed maturation and the ability of adults to buffer against poor conditions by searching a larger area for food, relying on fat stores, or abandoning pups (Costa, 2008). Instead, predator population changes often show up several years after the change in forage availability. Thus, indicators summarizing predator population size may not be useful for setting Herring quotas. Furthermore, population estimates for many of the key Herring predators are not always available (Table F-4). There are two sources of data, however, that may be useful to evaluate the health of Herring predators before a season of interest.

The first data source is the forecasted oceanic abundance of Sacramento River fall-run Chinook Salmon (SRFC), which is the largest central California Chinook Salmon stock (O'Farrell and others, 2013). Herring are very important to SRFC, as shown by available winter diet data. Chinook are relatively short-lived, at approximately 3-5 years, so their population more readily tracks changes in forage (i.e., Herring) availability. The SRFC population abundance has been tracked yearly since 1983 (Figure F-2). In 2008 and 2009 the fishery was closed because projected spawner escapement in the absence of fisheries was below the minimum escapement threshold of 122,000-180,000 fish set by the PFMC. The collapse of the SRFC was attributed to poor ocean conditions in 2005 and 2006, with weak upwelling and warm temperatures that resulted in limited prey availability and low survival for the 2004 and 2005 brood years (Lindley and others, 2009).

Table F-4. Herring predators and available local indices of predator health including population size, productivity, and survival.[1] The Sacramento River flows into San Francisco Bay (SFB). Southeast Farallon Island (SFI) is approximately 30 miles offshore, and Año Nuevo Island (ANI) is approximately 55 miles to the south of SFB. Abbreviations for organizations/agencies include Pacific States Marine Fisheries Commission/Regional Mark Processing Center (PSMFC/RMPC), NMFS, US Fish & Wildlife Service (USFWS), the National Park Service (NPS), and the Pacific Fisheries Management Council (PFMC).

Herring predator	Predator Index	Predator Index Source	Notes
Chinook Salmon	Sacramento fall run survival	Raw data CWT release and recovery from PSMFC/RMPC database (no online updates)	Analysis needed to estimate survival (Data obtained from Alex Letvin, CDFW)
Humpback Whale	Stock assessment/population size CA/OR/WA	J. Calambokidis/Cascadia Research; NMFS marine mammal stock assessment	http://www.nmfs.noaa.gov/pr/sars/
Common Murre	SFI population size, productivity	USFWS/Point Blue (no online updates)	Pop. size may no longer be updated annually
Harbor Seal	SFB population size, marine mammal mortality events	SFB state of estuary report, NMFS mortality event updates, SF NPS for more regional population size?	http://www.sfestuary.org, http://www.nmfs.noaa.gov/pr/health/mmume/events.html, http://www.sfnps.org
Pacific Hake	Stock assessment CA/OR/WA	PFMC stock assessment	https://www.pcouncil.org/groundfish/stock-assessments/by-species/pacific-whiting-hake/
Rhinoceros Auklet	SFI, ANI population size, productivity	USFWS/Point Blue (no online updates), Oikonos	http://oikonos.org/wp-content/uploads/2013/06/2016-ANI-report-2016_reduced_size.pdf

[1] Note that population size of upper-trophic predators usually does not vary in response to environmental influences in the same year that the population is measured (due to delayed maturity, etc.), except in the case of very extreme events which cause adult die-offs. Similarly, adult survival is fairly invariant except during extreme events which predators cannot buffer. Therefore, these are rarely good annual indicators.

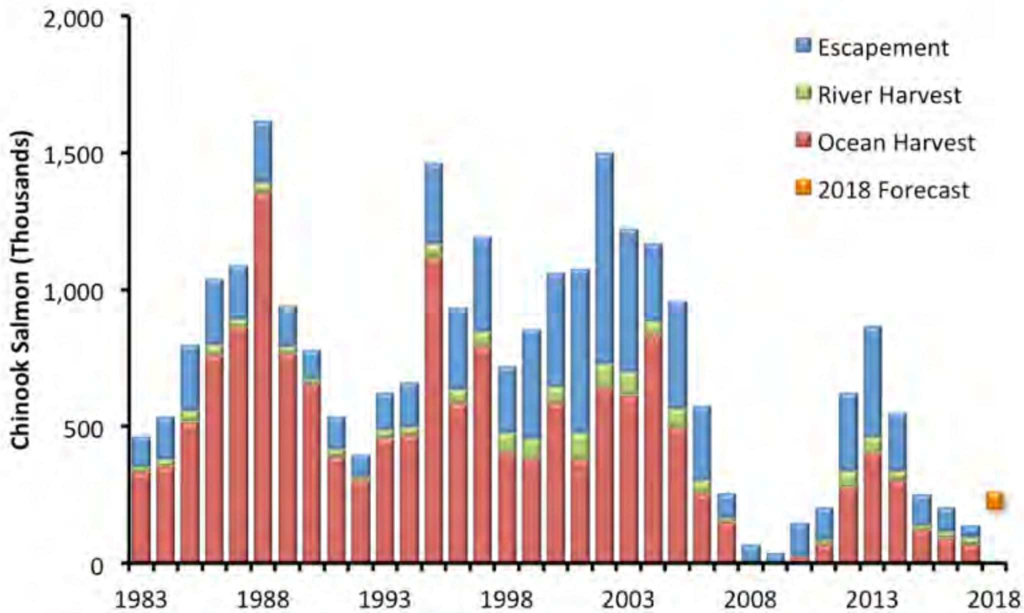


Figure F-2. Sacramento River fall-run Chinook Salmon population index, composed of escapement, river harvest, and ocean harvest (Reproduced from https://fishbio.com/field-notes/the-fish-report/poor-returns-2017-salmon-season).

While population abundance estimates are not available until after the season, Chinook Salmon pre-season ocean abundance forecasts for the SRFC are available in late February/early March from the Department, NMFS, and the PFMC. A comparison of these forecasts to the escapement thresholds set by the PFMC would provide an indicator of exceptionally poor years for Chinook Salmon. Low populations may be caused by issues other than available forage. For example, low population levels in 2015 through 2017 were attributed in part to drought, warm weather, warm streams and 95% below-normal snow-water equivalent storage (Harvey and others, 2017). However, Ralston and others (2015) found a strong relationship between the forage assemblages in the central CCE and the SRFC population index, suggesting that forage availability plays a strong role in population abundances. Given the high levels of Herring observed in Chinook Salmon diet compositions, the SFRC index may provide a useful indicator with which to track the health of a Herring predator.

The second data source available for tracking how predator populations may be impacted by low forage availability is the reporting of seabird and marine mammal Unusual Mortality Events (UME). Under the Federal Marine Mammal Protection Act, an unusual mortality event (UME) is defined as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response" (16 U.S. Code 1421h Section 410). UMEs are easily-observed phenomenon, generate substantial public interest, and may be related to food availability in the ecosystem. Specifically, for long-lived seabirds and pinnipeds, UMEs can signal the failure of buffering efforts and food stress, and result in juvenile and adult mortality measurable in real-time (Melin and others, 2010; Soto and others, 2004) Table F-5 provides a list of all documented UMEs for Common Murre and Rhinoceros Auklet in California since 1982 (the earliest year data was available). These species were selected as potential indicators because Herring have been found in the stomachs of these birds in the central CCE region (Table F-2). These data are available in a searchable database maintained by the United States Geological Survey (USGS), where various agencies can report UMEs, their locations, and their causes. This resource enables the Department to easily monitor any ongoing UMEs in the central CCE region, as well as help determine whether they may be caused by a lack of forage.

Table F-5. Unusual Mortality Events in California for Common Murre (CM) and Rhinoceros Auklet (RA). Data from USGS Wildlife Health Information Sharing Partnership (WHISPers) database. Accessed at https://www.nwhc.usgs.gov/whispers/searchForm on 10 November 2018. Search terms were California + Common Murre and California + Rhinoceros Auklet.

Start Date	End Date	Number Affected	Location	Species	Event Diagnosis
9/16/82	9/16/82	122	San Mateo, CA	CM	Open [suspect], Emaciation (NOS)
8/24/83	8/26/83	550	San Mateo, CA	CM	Open [suspect]
7/12/89	8/9/89	4000	Marin, CA	CM	Emaciation (NOS), Trauma (NOS)
2/7/90	2/19/90	563	Orange, CA	RA	Toxicosis (petroleum, NOS)
7/1/94	9/1/94	30	San Mateo, CA	CM	Open [suspect]
7/7/95	8/10/95	1500	Marin, CA; San Francisco, CA; San Mateo, CA; Santa Cruz, CA; Monterey, CA	CM	Emaciation (NOS)
1/1/05	8/31/05	1563	Santa Cruz, CA; Monterey, CA; Del Norte, CA; Humboldt, CA; Mendocino, CA	CM, RA	Emaciation (starvation)
2/4/07	2/18/07	100	Orange, CA	RA	Undetermined [suspect]
3/1/07	6/1/07	550	Monterey, CA	CM	Emaciation (starvation)
7/14/07	9/15/07	300	Humboldt, CA; Lincoln, OR	CM, RA	Emaciation (starvation) [suspect]
11/7/07	12/2/07	500	Santa Cruz, CA; Monterey, CA	CM, RA	Toxicosis (domoic acid) [suspect], Airsacculitis
4/15/09	6/20/09	1000	San Mateo, CA; Marin, CA; San Francisco, CA; Alameda, CA; Monterey, CA; Santa Cruz, CA	CM	Emaciation (starvation)
10/1/11	3/30/12	350	Ventura, CA; Santa Barbara, CA	CM	Emaciation (NOS)
8/14/14	2/28/15	3500	Grays Harbor, WA; Clallam, WA; Lincoln, OR; Clatsop, OR; Coos, OR; Sonoma, CA; San Luis Obispo, CA; Monterey, CA	RA	Emaciation (starvation), Parasitism (gastrointestinal/hepatic), Avian Pox [suspect]
8/4/15	11/1/15	5150	Marin, CA; San Francisco, CA; San Mateo, CA; San Luis Obispo, CA; Monterey, CA; Santa Cruz, CA	CM	Emaciation (starvation)
7/22/16	7/29/16	32	Humboldt, CA	CM	Undetermined
4/1/17	4/24/17	547	Ventura, CA; Santa Barbara, CA; Los Angeles, CA	CM	Toxicosis (domoic acid)
7/29/17	8/5/17	156	Humboldt, CA	CM	Emaciation (NOS), Toxicosis (domoic acid)

Herring were found to occur in the diets of two central CCE pinnipeds, California Sea Lions and Harbor Seals, and Table F-6 lists the UMEs observed in California, including those for California Sea Lions and Harbor Seals. There are a number of studies documenting Herring in the diets of Harbor Seals, though the available information suggests that Herring may be a more important prey species for Harbor Seals in the summer, when Herring school in feeding grounds such as in Monterey (Oxman, 1995). Two studies, one in 1991-1992 and one in 2007-2008, found no evidence of Herring in the diets of San Francisco Bay Harbor Seals, though seals have been observed eating Herring during fishing activities (R. Bartling pers. comm.). These studies also found that Herring occur less frequently in Harbor Seal diets than would be expected based on the relative abundance of Herring in local waters, and suggesting that Harbor seals preferentially target cephalopods and flatfish rather than Herring (Gibble, 2011; Trumble, 1995).

There are limited data for California Sea Lions, with the only published study finding that in Monterey Bay, Herring made up 0.1% of winter diets and 0.6-0.08% of spring diets, with no Herring observed in the summer or fall (Weise and Harvey, 2008). Unlike Harbor Seals, who have their pups at various rookeries throughout the state, including at sites in San Francisco Bay, in the spring (Gibble, 2011), California Sea Lions breed mainly on offshore islands ranging from southern California to Mexico, although a few pups have been born in central California locations (Lowry and Forney, 2005). For this reason, California Sea Lions may not be the best predator indicator for use in management of Herring because their most vulnerable life stage occurs in southern California and northern Mexico (Costa, 2008; National Oceanic and Atmospheric Administration, 2014a), a region with different prey availability and environmental conditions. Despite these limitations, Department staff have also observed California Sea Lions preying on Herring within San Francisco bay during the Herring fishing season (R. Bartling pers. comm.), and so they can be considered an indicator predator.

Based on data from other locations, it is possible that other California pinnipeds such as the Guadalupe Fur Seal and Northern Fur Seal eat Herring, but this has not been shown in diet studies from the central CCE, likely due to the lack of winter sampling. Such samples may demonstrate the importance of Herring to central California pinnipeds during this period, as has been shown for other pinnipeds such as Steller Sea Lions in Alaska (Willson and Womble, 2006; Womble and Sigler, 2006), and future research is needed to understand the significance of Herring to pinnipeds in the central CCE.

Mortality events caused by reasons other than poor forage conditions are unlikely to be improved by reductions in quota. Tables F-5 and F-6 show that a number of mortality events have been attributed to biotoxins or infectious disease. Brevetoxin and domoic acid are the most common biotoxins associated with marine mammal mortality events, primarily in California Sea Lions. Some of these biotoxin outbreaks, such as domoic acid, are more likely to occur in warm water events such as the UME for California Sea Lions during the 1998 El Nino (Table F-6). While forage conditions may have been poor in that year as well, the primary reason for the die off was attributed to the biotoxin. In addition, many of the events listed in these data sets occurred in areas outside of the central CCE, and thus may reflect poor forage conditions in other areas of the state. For example, the UME affecting California Sea Lions between 2013-2017 was centered primarily around rookeries in Southern California. This highlights the importance of considering the cause and location of UMEs prior to making management decisions.

Table F-6. Unusual mortality events for marine mammals in California. The species, year(s) of occurrence, and cause of the mortality event (if determined) are listed. Accessed on 6 November 2018 from https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events.

Year	Species Affected	Cause of Mortality Event
2013 – 2017	California Sea Lion	Ecological factors
2008	Harbor Porpoise	Ecological factors
2007	Cetaceans	Undetermined
2007	Large whales	Human interactions
2006	Harbor Porpoise	Mortality undetermined
2003	Sea Otters	Ecological factors
2002	Common Dolphins, California Sea lions, Sea Otters	Biotoxins
2000	California Sea Lions	Biotoxins
2000	Harbor Seals	Infectious disease
1999-2001	Gray Whales	Mortality undetermined
1998	California Sea Lions	biotoxins
1997	Harbor Seals	Infectious disease
1994	Common Dolphins	Undetermined
1992-1993	Harbor Seals, California Sea Lions	Ecological factors
1991	California Sea Lions	Infectious disease

Description of Decision Tree Process and Assessment Criteria

The information summarized above was used to develop a decision tree process to assist Department staff in considering ecosystem indicators in a transparent, reproducible method when setting quotas each year using the Harvest Control Rule (HCR). Given that the HCR is designed to protect the forage needs of predators through the use of a harvest cutoff, conservative harvest rates, and a quota cap, one of the primary objectives for this decision tree is to provide a means of alerting Department staff when conditions in the central CCE are unusually poor and a further reduction in the HCR harvest rate might be advisable to account for predator needs. Another primary objective is to identify when conditions in the region are such that a small harvest rate increase may be warranted. Finally, given the size and participation levels in the San Francisco Bay Herring fishery, staffing constraints, as well as the level of precaution already built into the HCR, there was a desire to utilize available data that were already summarized and readily available within the quota setting time frame.

With these objectives in mind, a decision tree was developed to identify which indicators should be considered during the quota setting process and the criteria for determining when quota changes (increases or decreases) may be warranted based on ecosystem conditions (Table F-7). This decision tree is designed to guide Department staff through analysis of the available information on predator population health and regional forage availability. The indicators included were carefully chosen to reflect the best available science on the interactions between Herring and their predators in the central CCE and the other forage species in the region.

The decision tree presented in Table F-7 is to be utilized after the Spawning Stock Biomass (SSB) of the San Francisco Bay Herring population is estimated (Section 7.6), and a preliminary quota has been identified using the HCR (Section 7.7.1). Department staff will apply the decision tree, beginning with Step 1, to determine whether an increase or decrease to the preliminary quota should be considered based primarily on changes in predator and regional forage indicators in the central CCE at the time of quota setting (late summer or early fall).

Step 1: Herring Spawning Stock Biomass

The first step in the decision tree assesses whether the current estimated SSB of the San Francisco Bay Herring population is greater than 20,000 short tons(t). Adjustment to the preliminary quota is not recommended when the SSB is less than 20,000t. When the stock is between 15,000 and 20,000t, a set quota of 750t is reserved to maintain access and viability to the commercial fishery while minimizing ecological impacts of harvest. When the stock is below 15,000t, the quota is zero and there is no need for adjustment. Alternatively, if SSB is greater than 20,000t, a change to the preliminary quota via a 300 ton (272 metric ton) adjustment may be recommended, and predator populations should be assessed by proceeding to the second step of the decision tree.

Table F-7. Decision tree to assess predator-prey conditions in the central CCE.			
Herring	1. Is the biomass estimate greater than 20,000t?	No	Do not adjust quota.
		Yes	Proceed to 2.
Predators	2. Is there an unusual mortality event in progress in California for one of the following species: Common Murre, Rhinoceros Auklet, Harbor Seals, or California Sea Lions?	No	Proceed to 5.
		Yes	Proceed to 3.
	3. Is the mortality event occurring in Central California (e.g., Sonoma, Marin, San Francisco, San Mateo, Santa Cruz, Monterey counties)?	No	Proceed to 5.
		Yes	Proceed to 4.
	4. Is the cause of the mortality event attributed to or exacerbated by lack of forage, and the Herring biomass estimate is < 40,000t?	No	Proceed to 5.
		Yes	Consider reducing quota.
	5. Is the forecasted ocean abundance of Sacramento River Fall Run Chinook Salmon < 180,000, and the Herring biomass estimate < 40,000t?	No	Proceed to 6.
		Yes	Consider reducing quota.
Regional Forage	6. Calculate whether YOY Hake, YOY Rockfish, YOY Sanddab, Market Squid, and krill in the central CCE are more than 1 standard deviation below the long term mean. These indicators are classified as "unusually low".		Proceed to 7.
	7. Calculate whether central CCE Adult Pacific Sardine and Adult Northern Anchovy are below 50% of the long term mean. These indicators are classified as "unusually low".		Proceed to 8.
	8. Calculate the number of forage indicators that are more than 1 standard deviation above the long term mean. These indicators are classified as "unusually high".		Proceed to 9.
	9. Are there currently > 5 forage indicators that are unusually low, and the Herring biomass is < 40,000t?	No	Proceed to 10.
		Yes	Consider reducing quota.
	10. Are there currently > 3 forage indicators that are unusually high, and the answer to lines 2, 5, and 6 is no?	No	Do not adjust quota.
		Yes	Consider increasing quota.

Steps 2-5: Predator Indicators

The next set of criteria (Steps 2-4; Table F-7) assess whether a quota reduction is advisable due to UMEs in predator populations that may be caused by lack of forage. Based on the available dietary studies linking predators in the central CCE to Herring, as well as the available data with which to assess predator population health, a suite of known Herring predators including Common Murre, Rhinoceros Auklet, Harbor Seals, and California Sea Lions were chosen (Table F-2). Humpback Whales have been observed to eat Herring in central and northern California, though in far smaller quantities than either krill or sardines (Clapham and others, 1997). Humpback Whales were not included as indicator species due to their long-distance migration patterns and large foraging grounds, which would make it difficult to link a mortality event to a specific region.

With respect to the decision tree, UMEs are limited to those that primarily occur in the central CCE region and those that are attributable to starvation. However, it is important to note that UMEs are also caused by non-forage factors, including infectious diseases or exposure to biotoxins such as domoic acid (Table F-6). Non-forage related UMEs would not warrant a reduction in the quota because it may take a long time to determine the cause of the UME due to laboratory processing of samples, or to even detect whether a UME has occurred. In the event of a UME where the cause is undetermined, no quota reduction is warranted. Without direct evidence of a forage-related cause, there would be no rationale to reduce the quota and limit fishing opportunity. Should the criteria outlined in questions 2, 3, and 4 all be met, the decision tree recommends that the Department consider a quota reduction via a 300 ton (272 metric ton) decrease in the harvest rate under the HCR.

For question 5, there is strong dietary evidence linking Chinook Salmon to Herring in the central CCE. Question 5 assesses the SRFC population, and recommends a decrease in the Herring quota if the forecasted oceanic abundance is below the upper limit (180,000 fish) of the target escapement range set by the PFMC (Pacific Fishery Management Council, 2011). The PFMC escapement target for the SRFC population is set annually, typically in April. The SRFC population is intensively managed, and pre-fishery ocean abundance forecasts are primarily driven by ecological conditions, as fishing is yet to occur (Pacific Fishery Management Council, 2019). There is no immediate way to determine whether low oceanic abundance is due to a lack of forage, but since Chinook Salmon are known predators of San Francisco Bay Herring, reducing the Herring quota may help maintain forage needs for the Chinook Salmon population should the pre-season ocean abundance salmon forecast fall below the escapement target range.

Steps 4 and 5 recommend quota reductions in response to predator UMEs and low salmon forecasts only when the SSB is less than 40,000t. When the SSB is larger than 40,000t, the Herring stock is at 40-50% of the average estimated unfished biomass (Appendices B and M) and will likely meet Herring predator forage needs without additional reductions in catch. However, at an SSB below 40,000t it may be warranted to reduce the quota if ecosystem conditions suggest that forage conditions in the central CCE are unusually low (as defined in Table F-3 and Table F-7).

Steps 6-10: Regional Forage Indicators

Steps 6-10 are designed to guide the Department through the process of assessing regional forage availability in the central CCE, and to determine if forage indicators confirm that prey conditions in the central CCE are unusually low or unusually high. The regional forage indicators rely on data publicly provided annually by the CCIEA project, and the rationale behind the use of these indicators and how the thresholds to define "unusually high" and "unusually low" indices are discussed in detail above (Table F-3). "Cold water/medium energy" taxa (defined as juvenile rockfish, juvenile Pacific hake, juvenile sanddabs, Market Squid, and krill) and "warm water/high energy" taxa (defined as Pacific Sardine and Northern Anchovy) fluctuate as the dominant forage assemblage over time (Ralston and others, 2015; Santora and others, 2017), and predators are adapted to switch between the two (Ainley and Boekelheide, 1990; Field and others, 2010; Sydeman and others, 2001; Weise and Harvey, 2008; Wells and others, 2017). For this reason, in years when more than five forage indices are unusually low, a quota reduction (via a 300 ton decrease in harvest rate under the HCR) may be warranted at SSBs less than 40,000t, because this would signal that both cold water taxa and warm water taxa are low, and that forage conditions are poor in the central CCE. Alternatively, if four or more indices were unusually high, this would signal that forage conditions are favorable in the central CCE, and a quota increase (via a 300 ton increase in harvest rate under the HCR) may be warranted.

Retrospective Analysis to Assess Performance of the Decision Tree

To assess whether the management recommendations produced by the decision tree are in line with the current management objectives for this fishery , a retrospective analysis was conducted in which the decision tree was applied to the available data each year from 1991-2015. The results are summarized in Table F-8 and discussed here. Note that for many of the indicators, data were only available to 1991, which was therefore the first year of this retrospective analysis.

This analysis indicates that the decision tree would have recommended quota reduction in one season (1995-96), based on a predator mortality event affecting Common Murre in central California, if the predictive model's SSB estimate of 23,500t had been used that year. However, had the previous season's (1994-95) SSB estimate of 40,000t been used, no quota reduction would have been recommended. The analysis also indicates that the decision tree recommended a quota increase for one season (2013-14), whether either the predictive model or previous season's empirical SSB estimate was used. This was due to high forage counts co-occurring with high SSB estimates that season.

The criteria used to determine when the quota should be reduced to account for very poor forage conditions is intended to detect situations in which both cold and warm taxa are unusually low, which would signal that the central

CCE is not functioning as it normally does (fluctuating between warm and cold water forage assemblages) and the possibility of an extreme lack of forage in the region is high. According to this framework, the lowest observed forage conditions occurred in 1998, when all five cold-water forage species were low. However, the Pacific Sardine and Northern Anchovy indices were high to moderate that year, so there was still some forage available, though it may not have been the preferred forage type for predators with more northern ranges. It should be noted that during this year the SSB of Herring was one of the lowest ever observed, because Herring have responded negatively to warm, low nutrient conditions in much the same way as other cold-water taxa in the central CCE. Had the management framework proposed in this FMP been applied that year the Herring quota would have been zero based on the estimated Herring SSB.

During the unprecedented NPMH in 2014 and 2015, in which waters were warm for an extended period of time, Pacific Sardine and Northern Anchovy remained unusually low while cold water taxa, in particular the juvenile rockfish indices, were unexpectedly high. As a result the decision tree did not indicate the need for a forage-based reduction in quota. However, during this period a number of indicator predators experienced forage related UMEs, suggesting a lack of forage despite the fact that the juvenile groundfish indices were high. This highlights the benefits of having multiple different indicators when using incomplete information, and points to a possible mismatch in the locations where these regional forage indicators are collected (primarily offshore) and the nearshore areas where predators of Herring are likely to be foraging, especially during the predator's breeding season when their movements are restricted. At this time however, these regional forage indicators represent the best available science, and more research is needed to develop indicators that more accurately capture forage availability in nearshore areas.

Table F-8. Decision tree retrospective analysis (1991-2015) results. "Yes" means the criteria were met, "No" means the criteria were not met, and Yes* means that the criteria were potentially met but it is difficult to determine what information would have been available at the time of quota setting. Gray-shaded cells indicate years where SSB was <20,000t. The numerals in rows 6-8 show the number of forage indices that met the criteria for those steps. Where applicable (steps 1, 4, 5, and 9), criteria were evaluated for SSBs derived from both the predictive model and previous season's empirical estimates. **indicates that either no SSB prediction for upcoming season, or no estimate for previous season was available.

	Step		Year (Fall)																								
			1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Biomass > 20,000 short tons	**1**	prev. SSB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	**	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No
		model	Yes	No	No	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes	**	No	No	No	Yes	Yes	Yes	Yes	No	No
Predator Mortality Events	**2**	Mortality event?	Yes	Yes	No	No	Yes	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes
	3	In Sf Bay Area?	Yes*	Yes*	No	No	Yes	No	Yes*	Yes*	No	Yes*	No	No	No	No	Yes	No	Yes	No	Yes	No	No	No	No	Yes	Yes
	4	prev. SSB	No	No	No	No	No	No	No	No	No	No	No	No	**	No	No	No	Yes	No	Yes	No	No	No	No	No	Yes
		model	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	**	No	No	Yes	No	No	No	No	No	Yes
Salmon	**5**	prev. SSB	No	No	No	No	No	No	No	No	No	No	No	No	**	No	No	No	No	Yes	Yes	No	No	No	No	No	No
		model	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	**	No	Yes	Yes	No	No	No	No	No	No
Forage Counts	**6**	Cold water taxa	0	1	0	0	1	1	0	5	0	0	0	0	0	0	3	4	4	2	0	0	0	0	0	0	0
	7	Warm water taxa	2	1	1	1	0	0	0	0	0	1	0	2	2	0	0	0	0	1	1	2	2	2	2	2	2
	8	High forage	0	1	1	0	1	0	1	1	0	0	0	0	0	1	2	2	1	2	0	0	1	2	4	4	4
Low forage	**9**	prev. SSB	No	No	No	No	No	No	No	No	No	No	No	No	**	No	No	No	No	No	No	No	No	No	No	No	No
		model	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	**	No	No	No	No	No	No	No	No	No
High Forage	**10**	> 3 high forage?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No
Years with recommended quota change		prev. SSB													**										Increase Quota		
		model					Reduce Quota											**							Increase Quota		

Altogether, this analysis suggests that the decision tree has the ability to inform the Department of unusually poor or productive conditions without being over-reactive. In a changing and highly variable ecosystem, it is impossible for a decision tree that is built on 25 years of historical observation to capture every possible combination of events. More information is needed to understand the relative importance and suitability of regional forage and predator indicators (particularly during winter). Therefore, precaution is appropriate when using ecosystem indicators to adjust management measures. This underscores the importance of Department discretion in considering potential ecosystem-based quota adjustments. Additionally, it will be necessary for the Department to update the indicators and thresholds underlying this decision tree as more research is done and our understanding of this system improves. In the meantime, however, management decisions must be made, and the information presented here suggests that the decision tree can serve as a useful framework for: a) incorporating ecosystem considerations into Herring management, and b) alerting fishery managers to unusual ecosystem conditions that may warrant further attention.

Appendix G Gears Used in the California Pacific Herring Fishery

Fishing technique has evolved somewhat in the Pacific Herring (Herring), *Clupea pallasii,* fishery since its inception. Two gear types (gill nets and purse seines) have been primarily used in the Herring roe fishery, though other types have also been used. This section describes the different types of gears used to target Herring.

Gill nets

While drift gill nets were used in the very early years of the roe fishery the legalization of set gill nets occurred in 1977 and set gill nets have been the primary gear used to take Herring. Gill nets are single panels of net that are set (anchored) and left to capture Herring by entanglement. Weights (along the bottom line) and floats (along the top line, also known as the cork line) hold the panel of webbing in a vertical position, to form a curtain-like wall of mesh. Since the 1998-99 fishing season, gill nets have been the only fishing gear allowed in the Herring roe fishery, following a regulation change that converted all round haul permits to gill net permits.

Purse seines

Purse seines are a type of round haul gear. A single panel of net is rapidly laid out from a vessel and positioned to encircle Herring. A small powered skiff aids in the encirclement process. Once encircled, the bottom-weighted line is pursed to create a bag. The bag volume is reduced by hauling the net onboard to concentrate the Herring to the point where they can be tested for roe quality, and if acceptable, removed with a large scoop net or submersible pump. Fish of unacceptable quality can be released. Purse seines were prohibited for use in the Herring roe fishery in 1998 over concerns about take of younger/smaller fish and mortality rates associated with testing and discarding unripe Herring.

Lampara

Lampara is a round haul gear that is set in a circle around a school of fish. It has no purse rings, and fish are forced into a bag by retrieving both ends of the net simultaneously. Lamparas are most effective in shallow water when the lead line rests on the bottom. Lampara boats are small, between 33 and 51 feet (ft) (10 to 16 meters (m)). The smaller boats use lighters (storage barges) with a capacity of 20 to 30 tons (18 to 27 metric tons) of fish. Lampara nets were used in the roe fishery until the early 1990s.

Beach Seines

Beach seines are fishing nets with floats at the top and weights at the bottom to keep them open. Nets are set in up to 10 ft (3 m) of water and dragged to shore along the ocean bottom. These were primarily used to catch bait and fresh fish during the early years of the fishery.

Cast Nets

Cast nets are 4 to 12 ft (1.2 to 3.7 m) radius panels of mesh webbing with a leadline attached to the circumference and a handline used to purse and retrieve the net. The net is thrown, or cast, by hand. The net opens up in midair and sinks when it hits the water, trapping the fish inside. Cast nets are only allowed in the sport fishery and are legal for recreational fishing north of Point Conception, but are prohibited in southern California because of their high efficiency. However, commercial fishermen have expressed to both California Department of Fish and Wildlife and the Fish and Game Commission that they are interested in using cast nets for the take of fresh fish. Cast nets are thought to produce a higher quality of fish compared to gill nets. However, the cast nets used in the sport fishery generally have a smaller mesh size than the current mesh size requirements for the gill net fishery, which can increase the number of smaller/younger fish selected.

Hook and Line

Hook and line gear is only used in the sport fishery, usually as part of rod and reel tackle from piers or jetties.

Open Pound (Herring Eggs on Kelp)

The San Francisco Bay Herring Eggs on Kelp (HEOK) fishery suspends giant kelp, *Macrocystis pyrifera,* from lines attached to rafts for Herring to spawn on in shallow water areas. The kelp is harvested near the Channel Islands or in Monterey Bay and then transported to San Francisco Bay. The kelp is then trucked to San Francisco and cut into approximately 6-inch lengths and hung on suspension lines on the rafts. A raft is defined as a temporary, mobile structure with a metal, wood or plastic frame not to exceed 2,500 square feet in total surface area. Timing is critical because cut kelp only lasts 8 to 10 days in San Francisco Bay waters before it begins to deteriorate.

The movement and maturity of Herring schools that enter the bay during the spawning season are monitored. Once a probable spawn location is determined a raft is towed by a vessel to the site and anchored. After a sufficient amount of eggs have been laid on the kelp, the blades are harvested, processed and exported to Japan.

Appendix H Timeline of Events in the Tomales-Bodega Bays Roe Herring Fishery

1972-73

The Tomales Bay Pacific Herring (Herring), *Clupea pallasii*, roe fishery got underway on 06 January 1973. The California State Legislature (Legislature) assumed control of the fishery over concerns of an unrestricted fishery, when the Governor signed the emergency legislation on 17 January 1973. Emergency legislation established a temporary (61 day) catch quota of 750 tons (681 metric tons) for Tomales Bay and San Francisco. Catch was made with round haul gear.

1973-74

With the last season's emergency regulations expired, the Legislature passed legislation establishing a 450 ton (408 metric ton) quota for the 1973-74 and 1974-75 season.

The Department of Fish and Wildlife (Department) was asked to conduct a 2-year (yr) study and assess the spawning biomass in Tomales Bay and San Francisco. At the end of the 2-yr study, regulatory authority of the fishery would revert to the Fish and Game Commission (Commission) who would set quotas based on the field studies. The concern for the safety of other bay users led to limiting the number of Herring permits. A lottery was conducted for the five Herring permits issued for Tomales Bay.

1974-75

In the 1974-75 season the quota was increased to 500 tons (454 metric tons) and was exceeded by 18 tons (16 metric tons). Only five permits were issued for the relatively small quota. Three lampara boats, one purse seiner, and one drift gill netter were drawn by lottery for the Tomales Bay roe fishery. However, there was concern that one large vessel could dominate the fishery. Therefore, no permittee was allowed to take more than 150 tons (136 metric tons). This represented the first step toward catch allocation.

1975-76

Legislative control expired after the 1974-75 season and regulatory authority over the Herring roe fishery reverted to the Commission. During the 1975-76 season, the Tomales Bay fishery expanded and a 600-ton (544 metric ton) quota was allocated to each vessel on an individual basis. Round haul vessels received 100 tons (91 metric tons) each and gill net vessels received 25 tons (23 metric tons) each. Round haul vessels were allocated a higher quota because of the larger crews and higher operating costs.

Five special permits were issued for Tomales Bay for Herring bait and fresh fish markets. There was a total of fourteen Herring permits issued for Tomales Bay. The Bodega Bay fishery began without a catch quota or permit limit.

1976-77

The Commission obtained control of the Herring fishery in all state ocean waters. Individual vessel quotas were eliminated for the 1976-77 season in favor of group or gear quotas. The Tomales Bay quota was increased to 825 tons (749 metric tons), and most of the quota increase in the 1976-77 season went to new gill net permittees. Seventeen Herring permits were issued for Tomales Bay (five round haul, seven gill net, and five special-gear permits (beach seine)) available on a first come, first serve basis. The seven Tomales Bay gill netters received 250 tons (227 metric tons) while the round haul quota was increased to 550 tons (499 metric tons). The Commission changed the 25-ton special bait and fresh fish allocation to a gear allocation for beach seines.

A separate quota of 350 tons (318 metric tons) was established for 24 new Bodega Bay permittees. Due to concerns regarding potential conflicts with other bay user groups, weekend fishing in Tomales Bay and Bodega Bay was prohibited from noon on Friday to sunset on Sunday. Anchored or "set" gill nets were allowed.

1977-78

Largely due to public sentiment, round haul vessels were permanently prohibited from participating in the Tomales Bay fishery. The total quota of 1,175 tons (1,066 metric tons) was allocated evenly between Bodega Bay and Tomales Bay. The 25-ton beach net allocation was included in the Tomales Bay quota, but a 10-ton fresh fish allocation was retained with five 2-ton permits.

1978-79

Tomales and Bodega Bays were combined into one permit area. The permit area was split into two platoons that fished alternate weeks. A spawning ground survey for Tomales Bay was not conducted this season. A maximum amount of 130 fathoms (fm)(two shackles; one shackle of net is 65 fm) of gill net was allowed for Tomales Bay.

1979-80

Tomales-Bodega Bay area Herring roe permits were capped at 69 permits. No new permits would be issued until the total permits fell below the cap. The depth of a gill net was restricted to no more than 120 meshes deep. No more than 260 fm (4 shackles) of net were allowed in Bodega Bay waters.

The Tomales and Bodega Bay quotas were combined for the 1978-79 season and the quota was increased to 1,200 tons (1,087 metric tons). Because 69 permitted fishing vessels would cause congestion on the fishing grounds, former Bodega and Tomales Bay permittees were split into two platoons and allowed to fish alternate weeks during the season. Each platoon was allocated 600 tons (543.5 metric tons).

1980-81

Tomales-Bodega Bay area Herring permits fell below 69 permits, when one permit was not renewed. The Commission then issued two new roe Herring permits. The Tomales gill net platoon system was modified to provide for an equitable catch. The first platoon was required to stop fishing when 100 tons (91 metric tons) were taken. The second platoon then fished until an additional 100 tons were taken, at which time the first platoon started fishing again, and so on until the quotas were met. Also, the fresh fish allocation was modified so that they could not be taken during the Herring roe fishery season.

Overcrowding on the fishing grounds in Tomales Bay was a problem. In order to minimize this problem, the number of Tomales Bay permits had to be reduced. The Commission created a 2-yr window of opportunity for Tomales Bay permittees to transfer to the San Francisco Bay Herring fishery. The intent was to reduce the number of Tomales Bay permits and combine the remaining permittees into one group for the 1982-83 season.

1981-82

Tomales-Bodega Bay area Herring permittees were allowed to exchange their permits for available San Francisco Bay permits to help alleviate crowding on Tomales Bay.

1982-83

Tomales-Bodega Bay area Herring permittees were allowed to transfer their permits to San Francisco Bay to help alleviate crowding on Tomales Bay. The number of Tomales Bay Herring permits was reduced to 41 permits, and no new permits would be issued, until there were less than 35 permits in Tomales Bay.

1983-84

The 41 permittees that chose to stay in Tomales Bay fished under a reduced quota of 1,000 tons (907 metric tons).

1985-86

Spawning ground surveys were conducted. However, due to the inability to locate spawning, which was usually indicated by bird and fishing activity, the spawning ground survey results were poor for this season. As a result, a cohort analysis was used to estimate the spawning biomass.

1986-87

The total gill net restriction in Bodega Bay was changed from 260 fm (four shackles) of gill net to 130 fm (two shackles) of gill net to make the amount of gear consistent in all permit areas. The provision for the use of drift gill nets was removed; therefore, only set gill nets were allowable.

1988-89

The Tomales Bay Herring fishery was closed after a record low 167 tons (152 metric tons) of spawning escapement in the season, which followed several seasons of low spawning and Herring abundance.

1989-90 to 1991-92

The Tomales Bay Herring fishery remained closed because spawning escapement did not exceed minimum escapement levels to support a fishery. Fishing was allowed to continue in the outer Bodega Bay. The outer bay fishery was modified by an increased closure zone around the mouth of Tomales Bay, and fishing was permitted only in Bodega Bay waters north of a line drawn due west, 240° magnetic, from the mouth of Estero de San Antonio. The closure zone around the mouth of Tomales Bay was designed to allow unimpeded access to Tomales Bay for spawning Herring. Department biologists speculated that Herring were displaced from Tomales Bay by unfavorable environmental conditions in the bay. Biologists hypothesized that Herring would return, if environmental conditions (such as, normal rainfall to reduce bay salinity) in Tomales Bay were more conducive for spawning.

1992-93

The season coincided with a remarkable return of spawning Herring to Tomales Bay, and the end of a 6-yr drought. The Tomales Bay fishery was re-opened for the 1992-93 season, when spawning ground survey results during the closure indicated improvement in spawning, and signaled that the spawning Herring population was potentially recovering. The Tomales Bay fishery was re-opened with conservative measures that included a quota based upon 10 percent (%) of the previous season biomass, an increase in the commercial gill net minimum mesh size to 2-1/8 inches (in), and a reduction of the maximum allowable amount of gill net used to one shackle (65 fm). An initial quota of 120 tons (109 metric tons) was established, with a maximum quota of 200 tons (181 metric tons), if the spawning surpassed the 2,000 ton (1,814 metric tons) escapement goal.

The outer Bodega Bay fishery was partially closed and the fishery was restricted to Bodega Bay and Tomales Bay waters south of line drawn due west, 240° magnetic, from the mouth of Estero de San Antonio.

1993-94 to 1996-97

Corresponding to the re-opening of the Tomales Bay fishery was the partial closure of the outer Bodega Bay fishery. In the 1993-94 season the Tomales Bay fishery boundary was confined within Tomales Bay, to District 10 waters south of a line drawn 252° magnetic, from the western tip of Tom's Point to the opposite shore. The outer Bodega Bay fishery was closed due to concern that this fishery intercepted potential Tomales Bay spawning fish. Additionally, the Department felt that an accurate estimate of the biomass of Herring that held in the outer bay could not be obtained, and that quotas for the outer bay fishery could not be based on a spawning biomass, as stated in management documents.

1997-98 to 2005-06

The 1997-98 El Niño event had a detrimental effect on Herring spawning populations throughout the state causing a loss of older age classes and a reduction in growth rates. Tomales Bay Herring fishermen expressed concerns that the 2-1/8 in gill net mesh size was no longer efficient in capturing Herring after the El Niño event and requested that the Department consider changing the minimum mesh size to 2 in. The industry stated that the increased number of "belly caught" Herring indicated that the 2-1/8 in mesh size was too large; a proper mesh size should capture Herring at the gills and not at the belly. The industry also pointed to poor catch rates caused by an improper mesh size, which reduced both the quality and quantity of the roe Herring landed. These two factors made the Tomales Bay fishery prohibitively unprofitable. The Department recommended to the Commission that a fleet wide gill net mesh study be done to assess the effects of a minimum 2-in mesh size on the current population structure.

2006-07

Thirty-five limited entry commercial Herring gill net permits were issued in Tomales Bay and the quota was set at 350 tons (318 metric tons) for the season. The quota was based on historical spawning biomass data. Two vessels actively fished during the 2006 to 2007 season. On 30 December 2006, two landings were made with a total of 1.2 tons (2,436 pounds (lb)) and a roe count of 12.1%. This was the only landing made for the season. Low market price and high operating costs attributed to the low effort. No commercial Herring fishing in Tomales Bay occurred between the 2006-07 and 2018-19 seasons (the time this FMP was drafted).

Appendix I Review of Survey Methods Used Estimate Abundance in San Francisco Bay

State of California **The Resources Agency**

M e m o r a n d u m

To: Patricia Wolf **Date:** July 14, 2003
Cc Eric Larson
Fred Wendell

From: John J Geibel 650 631-6117
Department of Fish and Game B MR-7 - Belmont

Subject: Comparison of Herring Egg spawn biomass estimates and Hydro-acoustic biomass estimates

I am presenting the results of my analysis of the two fishery independent herring spawning biomass estimators for the San Francisco Bay herring population with several options for future management of this fishery.

Background leading to this study

Two methods have been used to estimate the S.F. Bay herring spawning biomass, an egg deposition survey and a hydro-acoustic survey. Both surveys have been used in combination to try to arrive at the "best" overall estimate of herring spawning biomass. At times estimate based upon the two surveys has been greater than either survey alone. This can happen when each survey appears to have missed one or more schools of herring that the other found. At other times combining of the two surveys has resulted in biomass estimates between the two estimates. The biomass estimate used for setting the quota was greater than higher survey estimate 60% of the time, while 95% of the time the biomass estimate used for setting the quota was greater than the mean of the hydro-acoustic and egg spawn surveys (Table 1).

Requirements of the study

To compare the best estimator between two measurements requires either a true measure of the measurement being taken or a comparison of the two measurements against a third measurement. In the first case we can make a direct assessment of accuracy. In the second case we must look for consistency between the various measurements and conduct a more detailed analysis because we are now comparing three different measurements none of which is known to be better than the other. Consequently this analysis requires looking at both correlations and inconsistencies within and between measurements.

The Data

Data used in this analysis consisted of biomass estimates from two Coleraine model runs (a run with low maximum biomass and a run with high maximum biomass to encompass a range of possible spawning biomass estimates during the period from 1974 through 2002), biomass estimates from egg spawn surveys and from the hydro-acoustic surveys, the biomass estimates obtained from the combination of the egg spawn and hydro-acoustic surveys, and the egg spawn survey and hydro-acoustic survey with one year time lag (table1).

Coleraine – an age Structured Model

A description of data that were used to fit the model is included at the end of this memo. An age structured model, such as Coleraine, can be fit using all of the available data. The model fit is based upon a cohort reconstruction which is then compared to the age structured landings, both surveys, and CPUE index from the gillnet fishery. The advantage using the model is the lack of subjectivity in the model weighting and selection of data used in the fit. The cohort reconstruction also requires fitting of data between years to obtain the best fit through time.

Comparison Between and Among Estimators

I used excel to calculate correlations between all estimators and the estimators with the 1 year time lag. The lower modeled biomass run and the higher modeled biomass run had the highest correlation with a correlation coefficient of 0.98 (table 2). This very high correlation results from the two model biomass estimates following the same trajectory through time, even though the absolute difference in estimates was about 30%. This means that even if we are not confident in which model run to use for an absolute biomass estimate, the model runs are consistent in estimating the relative decline in the spawning biomass through time. The egg spawn survey has a slightly higher correlation with the lower biomass model run, 0.84 and 0.815 (table 2). The hydro-acoustic has low, non significant correlations with both model runs with a slightly higher correlation with the lower biomass model run, 0.206 and 0.158 (table 2). The biomass estimates obtained by combining the two surveys had a correlation coefficient in between those of the two surveys as one might expect, 0.49 and 0.453 (table 2).

Comparison of Survey with Themselves with a 1 Year Lag

The egg spawn survey compared with itself had a correlation coefficient of 0.707, $p < .0002$ (table 3). The hydro-acoustic survey biomass estimates with itself with a 1 year lag had a correlation coefficient of 0.19, $p > 0.4$ (table 3). And as expected the biomass estimates calculated from combining the two survey estimates with itself with a 1 year lag came out in between the other two estimates with a correlation coefficient of 0.33, $p > 0.13$ (table 3).

Discussion

The basic assumption in using an estimate of one seasons spawning biomass to set the quota for the next season is that the spawning biomass of year 1 will be a good estimator of the spawning biomass in year 2. If this assumption is not true, then there is little value of assessing the biomass from one year to the next. If this assumption is true then, we can examine how well each estimator can predict itself in the next season.

The regression of the egg spawn survey with itself with a 1 year lag can explain about 50% of the variability in the estimate. This leaves about 50% of the variation unexplained by the regression. Biomass estimates based on egg spawn survey are measured with error because we do not know the actual spawning biomass. Consequently both the dependent and independent variables are measured with error.

In addition the spawning biomass consists of the surviving older fish and new recruits. Differences in survival rates and recruitment between years will affect the actual biomass from one year to the next, so even if we could measure the spawning biomass in year 1 without error, we would not be able to predict spawning biomass in year 2 without error. In considering all of these factors, 50% seems reasonable.

The hydro-acoustic survey compared with itself with a 1 year lag can explain less than 4% of the variation from one year to the next and the regression slope is not significantly different from 0. Consequently if the hydro-acoustic survey can accurately estimate spawning biomass then we are left with the conclusion that biomass in year 1 is of little value in predicting biomass in year 2.

We do not know why the hydro-acoustic survey has these inconsistencies. One source of error could be multiple counting of some schools. Every effort is made to follow schools from the time they enter the bay, to the spawning areas, to their post spawning dispersal from the Bay. If herring were multiple spawners this could be a problem, but herring spawn only once. The assumption that the hydro-acoustic survey does not double count fish is difficult to test and is probably not true. But is it responsible for the occasional large discrepancy between itself from year to year and between it and the other estimators?

Age structured models will tend to underestimated true variance. For instance the effects of the 1997-98 El Niño in subsequent years was reduced by the model because the model accounted for the lack of older fish in the post El Niño years by reducing the number of fish in these cohorts in the pre El Niño years. Consequently the high correlations of the model runs and the same runs with a 1 year lag overestimate the ability of the model to predict the next years spawning biomass.

Conclusions

The hydro-acoustic survey is a poor estimator of itself. If the hydro-acoustic survey is unable to predict the next year's hydro-acoustic estimate, then it is of little help in establishing the quota for the following year's fishery. Likewise the correlation between the hydro-acoustic survey and the modeled biomass estimates is not significantly different from 0 and explains less than 4% of the variance of the model's historical reconstruction of the population (0.0369, Table 3).

The Egg spawn survey does a fair job of predicting itself in the next year (0.500, Table 3). In addition the egg spawn survey has a high correlation with the modeled biomass estimates, explaining 70% of the variance of the modeled biomass.

Recommendations

There are three options.

- Herring management can continue with the present spawn surveys and methodology.
- The hydro-acoustic survey can be discontinued.
- Both surveys can be discontinued being replaced by an age structured model.

The age structured model should be included with the first two options. The three options happen to fall out in order of costs. Conducting both surveys is the most expensive and also the most controversial. Whenever two different estimators are used, the higher estimator invariably is used resulting in a long term bias of overestimating biomass. In fact as was stated earlier, 60% of the time, the biomass used to set the quota was greater than higher spawning biomass estimate. And only in the first year of the hydro-acoustic survey was the biomass estimated used to set the quota less than the mean of the two estimates. Discontinuing the hydro-acoustic survey would probably cut field work cost by half. Eric Larson could come up with a more accurate estimate of cost savings.

Dropping both the hydro-acoustic and the egg spawn surveys and using an age structured model would be the most cost effective option. Considering the current fiscal crisis, this is the option that I would recommend. This option would eliminate the obvious bias in going with the higher of the two spawning biomass estimates or even worse of using the two estimates to produce a spawning biomass estimate greater than either of the two.

Regardless of options selected, commercial landings should still be sampled for age composition and other population parameters.

Description of data and parameters used in the herring assessment modeling

The CD contains several files with which the reviewers should become familiar. These are the excel input file, run8rec.xls, tracker.xls which lists the final model parameters used, and run8rec3o.xls which is one of the several files containing model output and graphs.

The input file – "run8rec.xls"

The input file is described in Appendix B of the Coleraine manual.

For the most part the excel input file is self explanatory with the labels describing the input data. The first three sections setup the excel file for data entry. For example the start year and end year set the range for catch data.

The next section names the gears used for the CPUE index, survey indices and commercial gears.

Projection Parameters

These values are used by the model to obtain projections based on the model parameters selected during the model run. I could not get this part of the model to work.

Priors

This section is explained in the model description and examples. This section lets the user determine the order that parameters are introduced into the model and the starting values with ranges to limit the model fits and CV's. The order of entry into the model is the first number. If that number is negative, the model uses the starting parameter value and does not try and fit within the given range. "Tracker.xls" also indicates the order of parameters entered and fit by the model using a color code. Red are those parameters fit in the first step, followed by yellow, green and then blue.
I set the selectivity for an asymptotic right side for both surveys and for the commercial catch by setting the initial value at 15 and -3 for fishing selectivity and -4 for survey selectivity.
I used several different orders for fitting of the parameters. Some would not work. However when the model could fit the parameters, the results were quite similar regardless of the order in which the parameters were entered and fit.

Likelihoods

These are described in Appendix B pp 49-50.

Fixed parameters

This is where the length-weight and length –age parameters are entered. We used a single sex model because the sizes are quite close.

The maturity ogive was 30% of 2's are mature and 85% of the 3's and 100% of all older fish.
I set the weight at age matrix to run from 1974 through 2003 with the first 10 years being an average weight over the entire period.

Data

Catch by method by year

Catch is in tons for round haul and for gillnet. The model does not handle zero catches. There was no gillnet fishery in 1974, so a minimal catch of 1 ton was used. Likewise since 1998 there has been no round haul fishery and so I again used 1 ton for these years.

CPUE

I used the CPUE from the gillnet fishery. The index was the total catch divided by the total number of landings. A constant CV of .5 was used for all years. This is a fairly rough estimator, but the model fit is quite good. I did not develop a CPUE index for the round haul fleet.

Fishery Independent Surveys

There are two spawning biomass surveys conducted in every years since 1982 and egg deposition survey and a hydro acoustic survey. The egg deposition survey goes back to 1979 and at least in recent years has had much lower variance than the hydro acoustic survey. Consequently although both estimators were used the CV was set a 0.5 for the egg deposition survey and 1 for the hydro acoustic survey. I tried setting the CV for the hydro acoustic survey equal to the egg deposition survey but the model would not fit the hydro survey until the CV was increased.

Catch at Age

This matrix contains 50 rows going from 1975 to 1997 for the round haul fishery and from 1976 to 2002 for the gillnet fishery. A constant sample size of 20 was used for all years.

Survey Catch at Age Data

In the first runs of the model, this data set was not used, but after our meeting with the fishermen, we decided to include this data set because it may give us some information of incoming yearclass strength. This data is derived from samples from the hydro acoustic survey. When added to the model it did indicate a small increase in herring biomass over the last two years.

We did not use the catch at length data. When first fitting the model, I did enter both catch at age and catch at length. However, I was advised that these two data sets would be highly correlated and should use only catch at age which I did. The model requires the last three catch at length dummy data sets,

The Output File “Tracker.xls”

The output file “Tracker.xls” is a file that keeps track of multiple model runs and parameters fits. The input file is listed for each run. The file listed is not the excel input file but a text file that is constructed from the excel input file for use by Coleraine.exe and model builder. I found this to be helpful because I could make small changes to the excel input file and then run the excel file to produce the text file which could be saved under a new name. This allowed me to have one working input file while saving the text files for documentation.
The fitted parameter values are listed with the order of entry to the model color coded with red indicating those parameters first fit followed by yellow, green, and blue. Parameters not fit by the model, the right hand side of the selectivity curves, are left uncolored.

Model Run Output Files

I have used a naming convention which adds an o to the name of the text input file to identify the excel output file. For example if the input file is named “run7.txt,” the excel output file would be called “run7o.xls”. This allows me to keep track of numerous model runs with their associated input files and output files. The workbook has the following spreadsheets.

General – graphs of general interest
SurNoSexCl
SurvC@L– Survey catch at length
CommC@L - Commercial catch at length
SurvS@A – Survey catch at age
ComC@A- Commercial catch at age
Surveys – Survey indices fits
SurSel – Survey selectivities
ComSel – Commercial selectivities
CPUE
Master – modeled data used to graph the results
Graphmaster – data used for general graphics

The catch at length spreadsheets are not of much use because we did not fit catch at length data. The main spreadsheet is “Master”. This contains all of the input data and data constructed from the modeled parameters such as the cohort reconstruction which is a matrix of numbers of fish at age by year for the period of the fishery being modeled. Other matrices produced are the spawning biomass, recruitment, etc. The graphs from each run make comparisons between runs very easy.

General Model Results

Maximum biomass estimates run from about 61,000 tons from “run8rec3o.xls” to 86,000 tons in “run11o.xls”. This would appear to be a reasonable range for maximum population of the San Francisco Bay herring population. The spawning biomass estimate for the 2002-03 from these model runs was respectively 16,600 tons and 24,300 tons. This gives us a present spawning biomass at about 27% of the maximum spawning biomass for “run8rec3o.xls” and 28% for “run11o.xls”.

The three factors that control the absolute size of the model population estimates are the natural mortality rate, the beginning population estimate and the maximum exploitation rates. By varying these parameters the population size can be varied. However even in runs in which the maximum population was over 100,000 tons the trajectory over time was quite similar indicating the present spawning biomass to be less than 30% of the maximum.

Confounding Factors El Niño

In 1995-96 and 1996-97 both the hydro acoustic survey and the egg spawn survey had relatively high spawning biomass estimates. The quota and the landings for the 1996-97 season were the highest in the history of the fishery. This would indicate that there actually was a high biomass of fish present in these years. However the strong El Niño of 1997-98 either displaced or killed most of these fish. In previous El Niño ’s the fishery experienced a significant decline in spawning biomass for that season, but adult fish seemed to return within the next year or two. This apparently did not happen following the 1997-98 El Niño .

The model can account for the loss of these fish in two ways. One would be to have a declining selectivity for these age groups following the El Niño . However I have run the model with an asymptotic right hand side of the selectivity curve. Consequently, when these older age fish do not show up in the fishery in the years following this El Niño , the model fits these age groups by lowering the numbers present in the years prior to the El Niño. This results in lower biomass estimates and high exploitation rates for those several years prior to this El Niño .

The bottom line would seem to be that the population will have to rebuild itself over a longer period than was the case with other El Niño’s. The model runs seem to indicate a slight rebuilding over the last three years. The two model runs indicate that the spawning population in 2002-03 has increased by 17% to 28% from the spawning biomass of 1999-2000.

Table 1. Biomass estimates by year for two model runs, egg spawn survey, hydro-acoustic, biomass used to set quotas, and egg spawn and hydro-acoustic with 1 year lag.

	Spawning Biomass Estimates								
Year	Low Coleraine Biomass Run	Low Coleraine Run 1 year lag	High Coleraine Biomass Run	High Coleraine Biomass Run 1 year lag	Egg Spawn Survey	Egg Spawn Survey 1 year lag	Hydro-Acoustic Survey	Hydro-Acoustic Survey 1 year lag	Biomass Used for Quota
1974	50,017	49,244	83,063	76,959					
1975	49,244	55,794	76,959	83,921					
1976	55,794	58,730	83,921	86,139					
1977	58,730	57,712	86,139	81,955					
1978	57,712	57,837	81,955	79,605		52869			
1979	57,837	58,368	79,605	79,810	52869	65441			52900
1980	58,368	56,059	79,810	74,690	65441	99495			65400
1981	56,059	44,956	74,690	60,140	99495	59243		67040	99600
1982	44,956	41,765	60,140	56,209	59243	40425	67040	29327	59200
1983	41,765	57,790	56,209	76,167	40425	46120	29327	29500	40800
1984	57,790	59,705	76,167	78,423	46120	49068	29500	36625	46900
1985	59,705	60,981	78,423	78,884	49068	56819	36625	40930	49100
1986	60,981	56,096	78,884	70,493	56819	68881	40930	58110	56800
1987	56,096	51,260	70,493	62,466	68881	66044	58110	65080	68900
1988	51,260	39,773	62,466	48,206	66044	63112	65080	58100	66000
1989	39,773	34,773	48,206	43,096	63112	45850	58100		64500
1990	34,773	29,318	43,096	36,544	45850	41020		32350	51000
1991	29,318	23,209	36,544	29,401	41020	13550	32350	18262	46600
1992	23,209	22,378	29,401	28,778	13550	23843	18262	40137	21500
1993	22,378	28,490	28,778	35,743	23843	20070	40137	33435	39900
1994	28,490	32,296	35,743	38,750	20070	57141	33435	92760	40000
1995	32,296	25,039	38,750	29,059	57141	41273	92760	88957	99000
1996	25,039	14,170	29,059	17,613	41273	5248	88957	17961	88520
1997	14,170	14,095	17,613	17,839	5248	13518	17961	42285	20000
1998	14,095	13,440	17,839	17,931	13518	12739	42285	21545	39500
1999	13,440	13,187	17,931	19,128	12739	12093	21545	46517	27400
2000	13,187	14,373	19,128	22,099	12093	15174	46517	36425	37300
2001	14,373	13,666	22,099	22,964	15174	13316	36425	40000	35400
2002	13,666		22,964		13316		40000		

Table 2. Correlation among different biomass estimators and among the egg spawn estimates and hydro-acoustic with one year lag

	Year	*Low Coleraine Biomass Run*	*Low Coleraine Run 1 year lag*	*High Coleraine Biomass Run*	*High Coleraine Biomass Run 1 year lag*	*Egg Spawn Survey*	*Egg Spawn Survey 1 year lag*	*Hydro-Acoustic Survey*	*Hydro-Acoustic Survey 1 year lag*	*Biomass Used for Quota*
Year	1									
Low Coleraine Biomass Run	-0.881	1.000								
Low Coleraine Run 1 year lag	-0.896	0.947	1.000							
High Coleraine Biomass Run	-0.934	0.980	0.956	1.000						
High Coleraine Run 1 year lag	-0.933	0.917	0.986	0.959	1.000					
Egg Spawn Survey	-0.776	0.840	0.657	0.815	0.633	1.000				
Egg Spawn 1 year lag	-0.776	0.868	0.840	0.864	0.815	0.707	1.000			
Hydro- Acoustic Survey	-0.072	0.206	-0.021	0.158	-0.061	0.600	0.146	1.000		
Hydro- Acoustic 1 year lag	-0.072	0.270	0.206	0.249	0.158	0.311	0.600	0.192	1.000	
Biomass Used for Quota	-0.367	0.490	0.270	0.453	0.239	0.821	0.397	0.936	0.353	1.000

Table 3. Regression analysis of three biomass estimator with themselves with a one year lag; egg spawn biomass, hydro-acoustic, and the combined biomass estimate.

Regression analysis of Egg Spawn Survey Biomass Estimates vs Egg Spawn Biomass Estimates with one year lag

Regression Statistics	
Multiple R	0.707318
R Square	0.500298
Adjusted R Square	0.476503
Standard Error	17890.18
Observations	23

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	6729244919	6729244919	21.02505	0.00016
Residual	21	6721226894	320058424		
Total	22	13450471813			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*.ower 95.0%*	*Jpper 95.0%*
Intercept	9867.849	7634.755538	1.29249056	0.210229	-6009.497	25745.2	-6009.497	25745.2
Spawn Survey	0.72497	0.158107243	4.58530825	0.00016	0.396168	1.053773	0.396168	1.053773

Regression analysis of Hydro Acustic Biomass Estimates vs Hydro Acustic Biomass Estimates with one year lag

Regression Statistics	
Multiple R	0.192207
R Square	0.036944
Adjusted R Square	-0.023247
Standard Error	21644.55
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	287544484.7	287544485	0.613773	0.444814
Residual	16	7495786800	468486675		
Total	17	7783331285			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*.ower 95.0%*	*Jpper 95.0%*
Intercept	35943.11	11731.88668	3.06371069	0.007423	11072.62	60813.59	11072.62	60813.59
Hydro	0.186868	0.238523931	0.78343668	0.444814	-0.31878	0.692516	-0.31878	0.692516

Regression of Biomass Estimates Used for Management vs the Same Biomass Estimates with one year lag *

Regression Statistics	
Multiple R	0.332904
R Square	0.110825
Adjusted R Square	0.066366
Standard Error	21473.38
Observations	22

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	1149426132	1149426132	2.49276	0.130057
Residual	20	9222117795	461105890		
Total	21	10371543927			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*.ower 95.0%*	*Jpper 95.0%*
Intercept	34728.36	12373.70145	2.80662668	0.010896	8917.284	60539.44	8917.284	60539.44
Combined	0.338152	0.214176163	1.57884755	0.130057	-0.108612	0.784915	-0.108612	0.784915

* These biomass estimaes are a combination of the egg spawn survey and the hydro-acuastic survey.

Appendix J Allocation Table for San Francisco Bay

Table J-1. Quota allocation table for San Francisco Bay. All quotas are in short tons. Beginning with the 1998-99 season, both numbers of permits fished and permits renewed (in parentheses) are provided.

Season	Sector	Number of Permits	Sector Quota	Notes
1972-73	Total	12	1500	
	Round haul	12	1500	
1973-74	Total	12	600	
	Round haul	12	600	
1974-75	Total	12	500	
	Round haul	10		150/permit
	Gill net	2		
1975-76	Total	58	3050	
	Round haul	24		100/permit
	Gill net	24		25/permit
	Special	10		5/permit
1976-77	Total	234	4000	
	Lampara	27	1500	
	Purse Seine	39	1500	
	Gill net	165	1000	
	Fresh fish	3	15	5/permit
1977-78	Total	290	5025	
	Lampara	29	1500	
	Purse Seine	30	1500	
	Gill net	226	2000	
	Fresh fish	5	25	5/permit
1978-79	Total	288	5020	
	Lampara	31	1500	
	Purse Seine	27	1500	
	Even gill net	110	1000	
	Odd gill net	110	1000	
	Fresh fish	10	20	2/permit
1979-80	Total	282	6020	
	Lampara	27	1500	
	Purse Seine	27	1500	
	Even gill net	109	1500	
	Odd gill net	109	1500	
	Fresh fish	10	20	2/permit
1980-81	Total	376	7250	
	Lampara	24	1500	
	Purse Seine	29	1500	
	Even gill net	112	1500	
	Odd gill net	111	1500	
	December gill net	100	1250	
1981-82	Total	383	10000	
	Lampara	27	2185	
	Purse Seine	24	1875	
	Even gill net	116	2070	
	Odd gill net	116	2145	
	December gill net	100	1725	
1982-83	Total	430	10399	
	Lampara	21	1792	
	Purse Seine	22	1719	
	Even gill net	126	2166	
	Odd gill net	134	2400	
	December gill net	127	2322	
1983-84	Total	430	10399	
	Lampara	21	2260	
	Purse Seine	22	1875	
	Even gill net	127	2088	
	Odd gill net	135	2088	

	December gill net	125	2088	
1984-85	Total	417	6500	
	Lampara	21	1131	
	Purse Seine	22	1079	
	Even gill net	126	1408	
	Odd gill net	128	1485	
	December gill net	120	1397	
1985-86	Total	416	7530	
	Lampara	21	1260	
	Purse Seine	22	1320	
	Even gill net	128	1683	
	Odd gill net	129	1683	
	December gill net	116	1584	
1986-87	Total	414	7530	
	Lampara	21	1260	
	Purse Seine	21	1260	
	Even gill net	128	1683	
	Odd gill net	127	1683	
	December gill net	116	1584	
	Roe on kelp	1	60	8 (product)
1987-88	Total	414	8500	
	Lampara	21	1422	
	Purse Seine	21	1422	
	Even gill net	128	1900	
	Odd gill net	127	1900	
	December gill net	116	1788	
	Roe on kelp	1	68	15 (product)
1988-89	Total	419	9500	
	Lampara	9	681	
	Purse Seine	31	2346	
	Even gill net	127	2089	
	Odd gill net	128	2123	
	December gill net	117	1999	
	Roe on kelp	5	262	59 (product)
	Allotment A and B	2*		5 (product)
*Two of the roe-on-kelp permittees were the successful bidders for allotments (A and B)				
1989-90	Total	413	9500	
	Lampara	3	228	
	Purse Seine	33	2508	
	Even gill net	126	2144	
	Odd gill net	128	2178	
	December gill net	115	1940	
	Roe on kelp	8	492	110 (product)
1990-91	Total	416	9500	
	Round Haul	34	2584	
	Even gill net	127	2142	
	Odd gill net	130	2192	
	December gill net	115	1940	
	Roe on kelp	10	642	144 (product)
1991-92	Total	406	7248	
	Round Haul	31	2074	
	Even gill net	128	1728	
	Odd gill net	131	1768	
	December gill net	116	1564	
	Roe on kelp		114	
1992-93	Total	413	5555	
	Round Haul	31	1485	
	Even gill net	127	1260	
	Odd gill net	129	1290	
	December gill net	114	1140	
	Roe on kelp	10	380	85 (product)
	Special Ed.	2	20	

1993-94	Total	276	2152	
	Round Haul	31	541	
	Even gill net	81	499	
	Odd gill net	83	511	
	December gill net	69	445	
	Roe on kelp	10	156	35 (product)
	Special Ed.	2	8	
1994-95	Total	418	4788	
	Round Haul	29	1102	
	Even gill net	133	1143	
	Odd gill net	131	1160	
	December gill net	113	1003	
	Roe on kelp	10	380	85 (product)
	Special Ed.	2	17	
1995-96	Total	423	6000	
	Round Haul	26	1238	47.6 (per permit)
	Even gill net	133	1481	
	Odd gill net	136	1514	
	December gill net	116	1291	
	Roe on kelp	10	476	107 (product)
	Special Ed.	2	22	
1996-97	Total	431	14841	
	Round Haul	25	2925	117 (per permit)
	Even gill net	133	3668	
	Odd gill net	136	3751	
	December gill net	116	3199	
	Roe on kelp	11	1278	289 (product)
	Fresh Fish	10	20	
	Special Ed.	2	54	
1997-98	Total	433	10748	
	Round Haul	25	2125	85 (per permit)
	Even gill net	133	2649	
	Odd gill net	136	2709	
	December gill net	116	2310	
	Roe on kelp	11	935	209 (product)
	Fresh Fish	10	20	
	Special Ed.	2	40	
1998-99	Total	457	3000	
	Even gill net	126 (148)	934	
	Odd gill net	128 (152)	959	
	December gill net	116 (134)	846	
	Roe on kelp	11	241	54 (product)
	Fresh Fish	10	20	
	Special Ed.	2	12	
1999-00	Total	456	5925	
	Even gill net	126 (148)	1870	
	Odd gill net	148 (149)	1858	
	December gill net	134	1694	
	Mesh size study	3	38	
	Roe on kelp	11	445	99 (product)
	Fresh Fish	10	20	
	Special Ed.	1	25	
2000-01	Total	452	2740	
	Even gill net	129 (149)	864	
	Odd gill net	131 (149)	864	
	December gill net	88 (133)	771	
	Roe on kelp	11	221	49 (product)
	Fresh Fish	10	20	
2001-02	Total	440	4474	
	Even gill net	140 (150)	1411	
	Odd gill net	146 (147)	1440	
	December gill net	88 (133)	1277	

	Roe on kelp	10	326	73 (product)
	Fresh Fish		20	
2002-03	Total	441	3540	10%
	Even gill net	135 (150)	1108	
	Odd gill net	139 (147)	1138	
	December gill net	58 (133)	1016	
	Roe on kelp	10	258	58 (product)
	Fresh Fish	(1)	20	
2003-04	Total	429	2200	
	Even gill net	97 (143)	701	
	Odd gill net	98 (145)	691	
	December gill net	79 (130)	628	
	Roe on kelp	10	160	35 (product)
	Fresh Fish	(1)	20	
2004-05	Total	417	3440	
	Even gill net	98 (141)	1101	
	Odd gill net	97 (141)	1101	
	December gill net	58 (124)	967	
	Roe on kelp	10	251	56 (product)
	Fresh Fish	(1)	20	
2005-06	Total	412	4502	
	Even gill net	70 (141)	1503	
	Odd gill net	68 (141)	1503	
	December gill net	61 (124)	1322	
	Roe on kelp	5	152	34 (product)
	Fresh fish	(1)	20	
2006-07	Total	410	4502	
	Even gill net	51 (141)	1503	
	Odd gill net	45 (141)	1503	
	December gill net	11 (124)	1322	
	Roe on kelp	4	152	34 (product)
	Fresh fish		20	
2007-08	Total	186	1094	
	Even gill net	40 (60)	373	
	Odd gill net	38 (71)	404	
	December gill net	0 (45)	280	
	Roe on kelp	10	76	17 (product)
	Fresh fish		20	
2008-09	Total	220	1118	
	Even gill net	60 (79)	383	
	Odd gill net	61 (81)	393	
	December gill net	2 (50)	243	
	Roe on kelp	2 (10)	79	18 (product)
	Fresh fish		20	
2009-10	Total		0	Fishery closed
	Even gill net			
	Odd gill net			
	December gill net			
	Roe on kelp			
	Fresh fish			
2010-11	Total	189	1920	
	Even gill net	52 (92)	918	
	Odd gill net	52 (93)	927	
	Roe on kelp	0 (4)	55	12 (product)
	Fresh fish		20	
2011-12	Total	194	1920	
	Even gill net	44 (93)	913	
	Odd gill net	43 (88)	932	
	Roe on kelp	0 (8)	55	12 (product)
	Fresh fish	0 (5)	20	
2012-13	Total	200	2854	
	Even gill net	66 (96)	1375	

	Odd gill net	62 (92)	1280	
	Roe on kelp	10 (10)	179	41 (product)
	Fresh fish	0 (2)	20	
2013-14	Total	198	3737	
	Even gill net	68 (95)	1739	
	Odd gill net	70 (93)	1703	
	Roe on kelp	2 (10)	295	66 (product)
2014-15	Total	201	2500	
	Even gill net	4 (98)	1181	
	Odd gill net	2 (93)	1121	
	Roe on kelp	0 (10)	198	44 (product)
2015-16	Total	183	834	
	Even gill net	19 (90)	391	
	Odd gill net	20 (83)	360	
	Roe on kelp	0 (10)	83	19 (product)
2016-17	Total	198	834	
	Even gill net	68 (90)	391	
	Odd gill net	70 (83)	360	
	Roe on kelp	0 (10)	83	19 (product)
2017-18	Total	201	834	
	Even gill net	4 (84)	385	
	Odd gill net	2 (80)	366	
	Roe on kelp	0 (9)	83	19 (product)

Appendix K History of Round Haul Elimination

Synopsis of Herring Round Haul Conversion Issue - Its Developmental History, Analysis of the Round Haul Association's 1995 Proposal, And Pertinent Management Issues

I. Developmental History of the Conversion

The conversion of round haul permits to gill net permits in the San Francisco Bay Pacific herring fishery was adopted by the California Fish and Game Commission (Commission) in August 1994 and implemented by the Office of Administrative Law in September 1994, following a rather lengthy developmental history. The regulation provides for voluntary transfer to gill net gear with a multi-year series of decreasing incentives, followed by a mandatory conversion of remaining round haul permits in 1998 (five fishing seasons after regulation implementation). Voluntary conversion to a special gill net permit authorizes the permittee to fish for two gill net quotas for as long as the permit is held by the current permittee. The following synopsis explains the State's actions on this issue and demonstrates that ample opportunity was provided for public input and joint development of this regulation.

The California State Legislature gave the California Fish and Game Commission management authority for the Pacific herring fishery in 1973 (Fish and Game Code Section 8550). Five round haul permittees were the first participants at the inception of the roe herring fishery in San Francisco Bay in 1972, with fleet size peaking at 66 round haul permits in 1976-77. Gill nets were subsequently authorized for use in the herring fishery in 1974, and both gear types have been active participants since then. Beginning in 1977, the Commission has authorized the exchange of round haul permits for gill net permits.

The Commission began the phase-out of round haul permits in the 1979-80 season, by deciding that no new round haul permits would be issued in the future for San Francisco Bay. (The Commission had already prohibited the use of round haul gear in Tomales Bay in the 1977-78 season, largely due to public sentiment). The planned gradual reduction of the round haul fleet by attrition was hindered by the 1989 action by the California State Legislature to allow the transfer (sale) of herring permits to qualified applicants. Previously, herring permits could only be transferred to partners, heirs, or siblings. Consequently, the round haul fleet stabilized at 42 permittees (of which, ten are presently fishing, instead, in the herring eggs-on-kelp fishery). Currently, 374 gill net, 39 round haul, and 3 "CH", or converted round haul, permits are issued for San Francisco Bay roe herring.

As cited above, the Commission had expressed its intent to create a gill net-only roe herring fishery in 1979. Fishing industry and scientists' concerns about long-term improvements to the fishery and resource status, and the lack of round haul permit attrition because of permit transferability prompted the Department in 1992 to initiate a public dialogue on this subject.

Department managers have a long notable history of "partnership" with the herring industry, seeking input through the Director's Herring Advisory Committee (DHAC), formal public hearings, and informal town hall meetings. The Department continued this policy, requesting guidance from herring fishery members at the very earliest stages of development of a round haul conversion proposal. Unfortunately, members of the herring round haul industry only provided few general comments. In the ensuing months leading to regulation adoption in August 1994, Department staff received **no** response other than several phone calls by permittees voicing general opposition to any actions. The following chronology lists the public meetings at which this subject was discussed, and individuals could provide input.

March 17, 1992 - Director's Herring Advisory Committee Meeting, Belmont.

March 16, 1993 - Director's Herring Advisory Committee Meeting, Belmont.

April 5, 1993 - Public Meeting on Pacific Herring Fishery, San Rafael.

April 16, 1993 - Round Haul Fishermen's Meeting, Youth Center, Dennis the Menace Park, Monterey.

August 23, 1993 - Fish and Game Commission Public Meeting, Sacramento.

March 21, 1994 - Director's Herring Advisory Committee Meeting, San Francisco.

April 11, 1994 - Public Meeting on Pacific Herring Fishery, San Rafael.

June 1994. The informative digest (listing proposed regulation changes, including the round haul conversion) of the STATEMENT OF PURPOSE FOR REGULATORY ACTION was mailed to all herring permittees by the Commission.

August 5, 1994 - Fish and Game Commission Public Meeting, San Luis Obispo.

August 26, 1994 - Fish and Game Commission Public Meeting, South Lake Tahoe.

The adopted herring regulations implementing the round haul permit conversion represent the culmination of a carefully considered process of analyses on the biological, social and economic effects of the transition to an all-gill net herring fishery in San Francisco Bay and a concerted effort to work with the herring industry. The phase-in of such a conversion over a five-year period is intended to provide a planning horizon to permittees and to reduce the short-term economic dislocation that some individuals may suffer during this transition.

II. Department Comments on 1995 Proposal of San Francisco Round Haul Association

The Department has reviewed the Round Haul Association's proposal and finds the proposed regulatory measures to have minimal benefits regarding the management concerns previously identified by the Commission and the Department. This proposal ignores several of the principal reasons for the conversion, including longstanding Commission policy and fishery yield analyses, and offers critiques of four of the Department's original concerns regarding round haul fishing for herring. The Department has the following brief comments to the four issues identified in the Round Haul Association proposal.

1) Wrap-and-Release Mortality The Department agrees that immediate or latent mortality to herring concentrated in a round haul net and subsequently released has not been quantified. However, anecdotal comparisons of the Monterey sardine fishery, and its daily capture and release of thousands of tons of sardines, and the San Francisco herring fishery are not appropriate. Pacific herring do not have swim bladders, thus will generally sink when dead, except for spawned-out herring which will float. It seems unlikely that dead herring would wash ashore and accumulate due to strong tidal currents in the Bay or that complaints would be registered. The Department is unaware of any studies on wrap-and-release mortality, for other Pacific herring round haul fisheries on the west coast are very brief with little opportunity for "test" net sets.

2) Differing Age Composition of Round Haul vs. Gill Net Catches As outlined in the original conversion analysis, the size and age compositions of round haul and gill net catches have always been very different (See below and Figures 1,2, and 3). The comment that 2- and 3-year-old herring composed less than 2% of the round haul catch recently is spurious. In the three herring seasons since the Department's analysis, the differential harvesting characteristics of the gears remain. Additionally, fishing has negligible or little influence on the recent increase in numbers of 2-year-olds in the population which is generally attributed to favorable environmental conditions.

3) Round Haul Gear Effects on Herring Behavior This issue was originally raised by the Department as a minor aspect of round haul fishing. The Department has never alleged that round haul nets "dam or impede tidal influences". The alleged disruption of herring schooling behavior was merely cited as an often-repeated claim by gill net fishermen which has not been substantiated by Department staff.

4) Vessel Traffic Disruptions The Department agrees that potential obstruction of vessel traffic by round haul vessels while fishing has historically not been an area of concern.

Round Haul Association Management Proposal The Association's proposal appears to be a return to pre-conversion regulations, with two modifications. First, shortening the herring season by ten days will not buffer fluctuations in year class strength, as alleged, nor will it have a demonstrable effect on fishery practices. Round haul permittees are primarily regulated by individual catch quotas, and little herring spawning (and corresponding fishing effort) has taken place in the last ten days of a season (early March). For example, during seven of the last ten years **no** round haul landings occurred at all in the last ten days of a season, and in the remaining three seasons, landings in a season's last ten days only ranged from 1 to 21 tons (<1 to 1% of total landings).

Second, it is unclear to the Department what incidental gear conflicts are to be eliminated, as stated in the industry proposal, by the proposed 8% reduction in the length of an individual net from 240 to 220 fathoms. The proposed reduction in fishing power may reduce individual catch volumes, but it is the non-selective nature of a round haul net itself that is responsible in large part for the size and age composition of herring catches.

III. Management Issues Identified in Original Department Conversion Proposal

The size and age composition of herring catches by round haul and 2 1/8-inch gill nets in the San Francisco Bay fishery are very different (Figure 1). Ages two, three and four herring are only partially vulnerable to gill nets in San Francisco Bay and are completely vulnerable (recruited) to the fishery at age five (Figure 2). In contrast, herring are completely vulnerable (recruited) to round haul nets at age two; and two-, three- and four-year-old herring dominate round haul catches (Figure 3). The two gear types are thus differentially harvesting the various age classes in the population.

1) Wrap-and-Release Mortality. An additional and unquantifiable mortality of herring has occurred in the fishery

1) Wrap-and-Release Mortality. An additional and unquantifiable mortality of herring has occurred in the fishery due to the practice of wrap-and-release of inferior-quality roe herring by round haul vessels. The discard of less desirable fish, whether from small size, low roe count, poor condition, in order to retain higher-valued fish is a practice called "high-grading". Regulatory efforts to halt this practice have had mixed success. The prohibition on this activity is largely unenforceable at night and is extremely hard to enforce at other times, unless an enforcement officer can observe and subsequently document that the discarded, or released, fish were in fact herring. This has proven to be extremely difficult in practice. Wildlife Protection staff have been told by prosecutors that an observer is needed on board each vessel to determine intent to discard herring and to sample fish within the net in order to successfully enforce this regulation. As a result, the fleet itself must voluntarily terminate this practice; but as long as a price differential exists for higher roe-count herring, wrapping-and releasing of inferior-grade herring will probably occur. Conversion to gill net-only fishing would greatly reduce this "high-grading" practice.

2) Egg Production-per-Recruit Analysis. Egg production-per-recruit analysis indicated a substantial increase in population egg production as a result of a shift in recruitment from age two, the entry age into the round haul fishery, to ages three and four - the ages of first entry into the gill net fishery. (Age-three herring are only partially catchable with the present 2 1/8 inch gill net mesh size). At the target harvest rate of 15% of the stock, a 16% gain in egg production would result from a shift in recruitment to age three and a 31% gain by deferring recruitment to age four (Figure 4). Although the relationship between the parent population size and the size of an eventual recruiting year class of fish is unknown for herring, the calculated increase in the population's egg production (due to the increased biomass of older, more fecund herring) would provide an additional measure of safety to buffer oscillations in year class strength.

3) Round Haul Gear Effects on Herring Behavior. Herring fishermen have alleged that the elimination of the use of round haul gear would reduce the disruptive effects of the gear on the pre-spawning, schooling behavior of herring in the Bay. Department staff have not attempted to substantiate this claim of a behavioral effect; it was included here because of repeated contentions by the gill net fleet of such an impact. The veracity of their concerns and the impact of disrupted pre-spawning behavior are unknown.

4) Weight Yield Per Recruit. A standard analysis of yield in weight of herring per recruit to the population predicted lower yields by a shift in the age of recruitment to the fishery from age two to ages three and four. In other words, an overall lower catch quota could result from a switch to an all-gill net roe fishery. At the target harvest rate of 15%, calculated weight yields would decline by 5 to 23% (Figure 5); but, given that only one-third of any annual quota is taken with round haul gear presently, this catch reduction would apply to only that part of the overall quota.

5) Roe Yield Per Recruit. Yield in terms of total weight of roe from the fishery would increase slightly by shifting recruitment to age three and decrease by as much as 13% by delaying recruitment to age four (Figure 6). An overall decrease in the tonnage of roe landed would probably be the expected outcome from conversion to an all-gill net fleet. The overall weight of roe may be less, according to this analysis, but actual roe counts (per ton, or per landing) would be higher. The quality of the resulting catch would be improved.

Social and Economic Aspects of the Proposal

1) Gear Conflicts. Gear conflicts between gill netters and round haulers would be eliminated. Historically, set gill nets and round haul gear have conflicted, particularly when spawning is underway or when herring are concentrated in small areas of the Bay.

2) Test Boat Program. The test boat program for the round haul fishery has reduced the prevalence of testing and releasing of low roe count fish, but the practice continues, according to Wildlife Protection staff. The inability to effectively enforce this regulation has diminished respect for other herring regulations, in particular, the gill net mesh regulation.

3) Individual Boat Quotas. Beginning with the 1981-82 season the total round haul quota was divided equally among the permittees and became individual allocations or quotas. These quotas ease competition among round haul vessels and increase the economic value of the catch, as permittees become more selective in their retained catch. But this selectivity encourages "high grading" of herring through wrap-and-release with resultant discard mortality of inferior fish. The fishing power of a seine or lampara net is considerable, and the mortality of many tons of herring at a time may occur due to wrap-and-release practices. Individual boat quotas are not routinely employed with the gill net fleet except occasionally to slow the pace of the fishery.

4) Fishing Power of Round Haul Nets. The catching power or capability of a herring seine or lampara net can greatly exceed a vessel quota at low quota levels. This may encourage the discard of surplus catch to ensure the attainment of an individual quota or may encourage the capture and landing of herring in excess of an individual quota. Anecdotal evidence suggests that such practices are commonplace, but documenting and citing permittees for such offenses is very difficult. The under-reporting of landings is also a problem with the gill net fleet, but the harvesting capacity of a gill net is considerably less than that of a round haul net.

5) Economic Value of Round Haul versus Gill Net Catches. The ex-vessel prices of round haul-caught herring are typically 33 to 60% less than an equivalent amount of gill net-caught herring (five-year averages were $631 and $1450 per ton for round haul and gill net catches), because gill net-caught herring typically are larger, with larger roe sacs and higher roe yields.

Appendix L Mesh Size Changes and Rationale

Gill net Mesh Size in the California Herring Fisheries
Historical Background Notes – Detailed Notes

This information is a summary of mesh size and mesh measurement changes to regulations for herring gill net fisheries in California from the 1976-77 season to 2003-04. The information covers all fisheries, Crescent City, Humboldt Bay, Tomales Bay and San Francisco Bay. In summary, none of the mesh size changes are based on experimental data or study conducted prior to regulatory change. All of the changes to the mesh size are on the minimum mesh allowed; the maximum has remained unchanged since a mesh size range was specified for the 1976-77 season. The maximum mesh size was stated, originally, in Fish and Game Code, and was most likely the source of establishing the limit; there is no reference in the files as to the rationale for a maximum mesh size. Many of the mesh size changes were at the request of the industry. The changes to the method of mesh measurement have been at the request of industry, Department enforcement and Department biologists.

The references for this information are the Director's Herring Advisory Committee (DHAC) meeting minutes and the Section 163, Title 14 CCR regulatory documents (Pre-publication of Notice/Initial Statement of Reasons, Pre-Adoption Notice and Final Document and regulations) unless otherwise noted. Information in quotation marks is a direct quote; all other information is paraphrased from the document referenced for that year. Personal names have been removed and replaced with "Industry", "Department staff", or "Department enforcement personnel" where appropriate. Information on regulations under each of the bulleted sections comes from Section 163 of Title 14 unless otherwise noted. Information under the section "Notes from the DHAC meeting minutes" is taken directly from the DHAC meeting minutes on file for that year. Information on regulatory changes is from DHAC meeting minutes and regulatory documents. See table at the end of this section for documents used for each year.

- 1975-76 Season. Draft regulations for this season are on file. There is no reference to minimum or maximum mesh size.

- 1976-77 Season. Mesh size regulations: The length of meshes of any gill net shall not be less than 2 inches or greater than 2 ½ inches. (Section 163, Title 14, CCR) The upper limit of 2 ½ inches for districts 11, 12 and 13 was stated in §8688 of the Fish and Game Code. "These changes will alleviate the concerns expressed by the commercial fishermen regarding the use of gill nets to take herring while still affording adequate protections to the herring resource as well as important sport species (October 6, 1976 letter from the Director to the Commission). The October 6, 1976 letter specifies a minimum of 1 ½ inches; a 2 inch minimum was specified in the regulations apparently as a result of earlier industry input and correspondence dated December 15, 1976.

- 1980-81 Season. Mesh size regulations: Provision for fresh fish mesh size of no more than 1 ¾ inches and distinction between roe fishery and fresh fish fishery. (Section 163, Title 14, CCR)

Notes from the March 17,1981 DHAC meeting minutes:

(Net measurement and mesh size) A survey questionnaire was distributed to gill net permittees prompted by the differences in production which resulted form the use of various mesh sizes. A DHAC member stated that many gill netters switched to smaller (2 inch) mesh nets this year because of the abundance of smaller fish and there was concern that extensive use of 2 inch mesh would impact the resource. Department staff presented the following results from the fish samples collected during the season:

Mesh size (inches)	Average Roe Recovery (Percent)	Percent Females	Ave. Length (cm)	Age Composition
2 ¼	18.1	75	20	93% of samples age 4-6
2 1/8	17.3	70	19.5	93% of samples age 3-5
2	14	58	?	84% of samples age 3-4

A lengthy discussion followed on the issue of minimum mesh size. It was decided to recommend 2 ¼ inch minimum mesh size for San Francisco Bay, Humboldt Bay and Crescent City and a 2 1/8 inch minimum mesh size for Tomales Bay, with a provision that would allow the Director to reduce the minimum mesh size to 2 inches after February1 if warranted.

- 1981-82 Season. Mesh size regulation unchanged. However in the August 12, 1981 Pre-Adoption Statement under "Summary of primary considerations raised in opposition to the proposed action and reason(s) for rejecting those considerations" in response to item 3, "Restrict the length of meshes of gill nets to 2 ¼ - 2 ½ inches", the response reads, "Current regulations provide that the meshes of gill nets shall not be less than 2 inches or greater than 2 ½ inches. This request is based on a desire, by some fishermen and processors, to restrict the catch to larger herring which are economically more valuable in the marketplace. However, there is no biological justification for implementing more restrictive mesh size regulations and such considerations are beyond the scope and authority of the Department."

File Notes: There are two interesting letters from industry that consider the option of increasing the minimum mesh size from 2 to 2 ¼ inches. There is a lot more information in both of these letters; here are excerpts from both:

"As you know, although 2 to 2 ½ inch has been the legal range of mesh size, the 2 ¼ inch mesh has been used by approximately 90 percent of the fishermen. This mesh size produces primarily five year olds and up herring and the best roe recovery available." "The problems with the 2 inch mesh are several: 1. It harvests stocks down into the three-year age class. This defeats the idea of harvest by gill net to take mature, older age herring while allowing younger stocks to spawn and return to sea." DHAC member, letter to the Director dated July 19, 1981.

"As a resource held as a public trust, the department should look beyond merely protecting the resource and assure that the maximum value is gained from this resource." "Without the department making clear its intent soon on mesh sizes, there will be a mad dash for nets with fishermen being uncertain of what mesh size to purchase. The industry, by itself, cannot regulate mesh sizes, since there is one overall quota and each fisherman must work to catch as much as possible." Industry Representative, letter to the Director dated July 10, 1981.

- 1982-83 Season. Mesh size regulations: In Tomales and Bodega Bay the length of the meshes of any gill net used in the roe fishery shall not be less than 2 inches or greater than 2 ½ inches. In all other permit areas the length of the meshes of any gill net used in the roe fishery shall not be less than 2 1/4 inches or greater than 2 ½ inches from November 28 through January 14. On or after such date the Director may, if the established fishing quotas are not filled and such action will not impact the herring resource, authorize the use of 2 1/8 inch or 2 inch minimum mesh for gill nets used in the roe fishery. (Section 163, Title 14, CCR)

Notes from the March 29, 1983 DHAC meeting minutes:

(Net measurement and mesh size) "A general discussion followed regarding minimum mesh sizes and current measuring techniques used by the Department's enforcement personnel in determining mesh size. It was noted that present methods were not adequate for the highly elastic small mesh monofilament webbing used for herring gill nets. As a result, some fishermen were actually using nets which were constructed of webbing less than minimum size, although legal when measure by the standard means. The director stated that the Department would develop an alternative measuring method for herring nets which would ensure compliance with the minimum mesh requirements established by the Commission." (New paragraph) " It was also suggested, and agreed upon, that the minimum mesh size for gill nets used in the XH fishery would remain at 2 ¼ inches, with a minimum of 2 1/8 inch mesh provided for beginning with the opening of the regular season on January 2, 1984." (DHAC Meeting Minutes, March 29, 1983)

Complaints were registered, by enforcement and industry, of the use of undersize webbing and the possible development of a standard measurement device using knot to knot measurement. (April 14, 1983 Herring (Public) Meeting Minutes/Notes)

- 1983-84 Season. Mesh size and measurement regulations: In Tomales and Bodega Bay the length of the meshes of any gill net used in the roe fishery shall not be less than 2 inches or greater than 2 ½ inches. In all other permit areas the length of the meshes of any gill net used in the roe fishery shall not be less than 2 1/4 inches or greater than 2 ½ inches from November 27 through December 16. From January 2 through March 30 the length of the meshes of any gill net used in the roe fishery shall not be less than 2 1/8 or greater than 2 ½ inches. The meshes of any gill net used by the fresh fish permittees shall not be greater than 1 ¾ inches.
  Subsection (f)(2)(G) was added to read:
  (G) Mesh size of gill nets authorized to take herring will be determined by the following method: (1) Suspend a minimum of eleven meshes between a fixed point and a maximum of one pound weight. (2) At least 50% of the meshes, when measured between the knots of or inside the points at which the meshes are joined of each mesh, using a standard stainless steel wedge of appropriate gauge without force, shall not be less than the mesh size of nets authorized pursuant to subsection (f)(2)(B) of these regulations. (3) Beach nets may only be used in Tomales Bay. No permittee may fish more than 75 fathoms of beach net. (Section 163, Title 14, CCR)

Notes from the March 26, 1984 DHAC meeting minutes:

(Net measurement and mesh size) Industry brought up the issue of undersized nets used in the fishery and the measuring method and there was a general discussion as to whether it was appropriate, or necessary, to amend or change the existing regulations.

Industry also discussed the questionnaire sent out to all San Francisco Bay gill net permittees, and the responses (43) received to date:

Minimum mesh size	2 ¼ inch	2 1/8 inch	2 inch
December (XH)	56%	37%	7%
January - March	21%	62%	17%
Individual Quota (bag limit)	Yes = 67%	No = 33%	

One DHAC member recommended a minimum mesh size of 2 1/8 inches for the entire season, including the XH fishery. A general discussion followed on mesh size, manufacturer's specifications, lead time when changing mesh size regulation, etc. The general consensus of the group was to retain the current regulations.

Subsequent results of this questionnaire (183 responses/386 questionnaires sent = 47%. This is broken down into December and Odd/Even Platoon responses:

XH returned 54 responses

Minimum mesh size	2 ¼ inch	2 1/8 inch	2 inch
December (XH)	28%	54%	19%
January - March	9%	52%	17%

Odd/Even returned 129 responses

Minimum mesh size	2 ¼ inch	2 1/8 inch	2 inch
December (XH)	50%	29%	7%
January - March	11%	63%	20%

As a result of this questionnaire, the Department amended proposals for the 1984-85 season regulations to provide for the use of 2 1/8 inch minimum mesh for San Francisco Bay gill nets used in the December (XH) fishery. "The majority of permittees responding to the latest herring questionnaire clearly supported this proposal which will provide uniform mesh size requirements for al San Francisco Bay gill nets used in the herring-roe fishery." (Letter from the Director to the DHAC members dated July 12, 1984)

In a letter dated July 3, 1984, Department biologists expressed the opinion that the minimum mesh size for the December fishery remain the same and provided rationale and catch curves from variable mesh gill nets and commercial catch in explanation.

- 1984-85 Season. Mesh size regulations: In Tomales and Bodega Bay the length of the meshes of any gill net used in the roe fishery shall not be less than 2 inches or greater than 2 ½ inches. In all other permit areas the length of the meshes of any gill net used <u>or possessed</u> in the roe fishery shall not be less than <u>2 1/8</u> inches or greater than 2 ½ inches. The meshes of any gill net used by the fresh fish permittees shall not be greater than 1 ¾ inches (Section 163, Title 14, CCR)

Notes from the March 19, 1985 DHAC meeting minutes:

(Net measurement and mesh size) There were no complaints about mesh size noted in the DHAC meeting minutes. Department staff noted the higher proportion of males and 3 year old fish in the December gill net catches were a reflection of the use of smaller mesh gear.

An increase to the fresh fishery mesh size from 1 ¾ to 2 inches was recommended by industry based on the difficulty of obtaining 1 ¾ inch mesh from local dealers and the use of 2 inch mesh would allow fresh fish permittees the opportunity to take larger fish for marketing purposes. "The Department has determined that the use of 2 inch mesh will not result in any adverse impact to the resource, and has proposed such an amendment in the 1985-85 herring regulations." (Pre-Adoption Notice, July 8, 1985)

- 1985-86 Season. Mesh size regulations: In Tomales and Bodega Bay the length of the meshes of any gill net used in the roe fishery shall not be less than 2 inches or greater than 2 ½ inches. In all other permit areas the length of the meshes of any gill net used <u>or possessed</u> in the roe fishery shall not be less than <u>2 1/8</u> inches or greater than 2 ½ inches. The meshes of any gill net used by the fresh fish permittees shall not be greater than 2 inches (Section 163, Title 14, CCR)

Notes from the March 4, 1986 DHAC meeting minutes:

(Net measurement and mesh size) A proposal was made by Department enforcement personnel to remove the language in subsections (f)(2)(G)(1) and (2) of Section 163, Title 14, CCR because the "method of measurement which is impractical and in conflict with Fish and Game Code Section 8602. Fish and Game Code Section 8602 has been upheld in court (Pennisi vs. California) and I see no benefit to the measurement described in Section 163." (Memorandum dated March 4, 1986 from Enforcement personnel to the Department) Subsection (f)(2)(G)(3) remained in the regulations under subsection (f)(3). This language was removed for the 1986-87 season.

A DHAC member proposed to limit gill nets to 2 ¼ inch mesh size only in the Humboldt Bay fishery.

- 1986-87 Season. No changes to mesh size or mesh measurement methods in regulation.

Notes from the March 4, 1987 DHAC meeting minutes:

(Net measurement and mesh size) Department enforcement noted that following the seizure of an undersized net, a number of abandoned nets with undersized mesh were found on the docks the following day.

A DHAC member proposed establishing the minimum legal mesh size at 2 ¼ inches in Humboldt Bay and Crescent City, because essentially all existing permittees are using 2 ¼ inch mesh nets at the present time and they wish to insure that the quality of the fish remains the same in the future should new, or additional, permittees enter the fishery.

- 1987-88 Season. Mesh size regulations: In Tomales and Bodega Bays the length of the meshes of any gill net used or possessed in the roe fishery shall not be less than 2 inches or greater than 2 ½ inches. In Humboldt Bay and Crescent City Harbor the length of the meshes of any gill net used or possessed in the roe fishery shall not be less than 2 ¼ inches or greater than 2 ½ inches. In San Francisco Bay the length of the meshes of any gill net used or possessed in the roe fishery shall not be less than 2 1/8 inches or greater than 2 ½ inches. The meshes of any gill net used or possessed by fresh fish permittees shall not be greater than 2 inches. (Section 163, Title 14, CCR)

Notes from the March 25, 1988 DHAC meeting minutes:

(Net measurement and mesh size) Industry noted that "under the present system, 2 inch mesh can easily pass as 2 1/8 inch mesh because of the elasticity of the monofilament webbing".

- 1988-89 Season. No changes to mesh size or mesh measurement methods in regulation.

Notes from the March 20, 1989 DHAC meeting minutes:

(Older fish in catch) "The Department biologist noted that gill net catches were dominated by 4, 5 and 6 – year old fish, similar to the previous season (1987-88). However, it had been expected that the landing would be dominated by 5, 6, and 7 – year old fish. In the biologist's opinion, the fact that they were not is reflective of the need to go to larger mesh gill nets. Also, the landing showed a 50/50 sex ration when it should have been 60/40 (females to males) or higher. This is further evidence of the need for larger mesh gill nets." The minutes also note an abundance of 3 and 4 – year old fish in the Tomales Bay catch "reflective of the need for larger mesh gill nets".

(Net measurement and mesh size) "He (Department enforcement) noted that the elasticity of today's net material made it possible for 2 inch nets to easily meet the standards of a 2 ½ in net gauge." "(Department enforcement) said that the fishermen's concern is that next year some individual will use less than 2 inch mesh". "In his (DHAC member) opinion, the gill net mesh size is critical and 2 1/8 inch mesh is the absolute minimum that should ever be used. He favored a previous regulation of several years ago that require 2 ¼ inch minimum mesh in December through the first two weeks in January. After that date 2 1/8 inch mesh was allowed. He stated that much of the fleet was using 2 1/16 inch mesh and some were even using 2 inch mesh. He believes the Department need to change the "measuring" law and suggests that legislation be introduced to do so."

(Recommendations for 1989-90) "The first recommendation was to increase the minimum mesh size for gill nets to 2 ¼ inch, with at least #7 monofilament webbing, beginning with the 1990-91 season."

Two options were provided to the Commission to address the issue of the decrease in average size and quality of fish landed in the herring fishery ("apparently due to the increased use of smaller-mesh nets"). Option One: An increase in the gill net minimum mesh and twine size to 2 ¼ inch, using No. 7 monofilament for San Francisco Bay and 2 1/8, using No. 7 monofilament for Tomales-Bodega Bay, beginning with the 1990-91 season. Also, a gill net closure in south San Francisco Bay (i.e. "BANZAI") beginning with the 1989-90 season. Option Two: Individual gill net quota of 17 tons per permittee in San Francisco Bay. This option also would include provisions to restrict the number of herring buying locations to four areas (Sausalito, Oakland, Pier 33, and Pier 45 – San Francisco), prohibit the unloading of fish between 10 p.m. and 6 a.m., and shortening the overall fishing season by two weeks. It appears that neither of these options was chosen, and there is no justification reflected in the notes.

- 1989-90 Season. No changes to mesh size or mesh measurement methods in regulation. Apparently a new method of measuring mesh size was implemented, but is not reflected in the regulations or in the DHAC meeting minutes (Pre-Adoption Notice dated July 11,1990).

Notes from the March 14, 1990 DHAC meeting minutes:

(Net measurement and mesh size) The Department attributed an increase in roe count in the XH fishery to better compliance with the 2 1/8 inch mesh. A DHAC member noted that although the average roe counts were up during the past season, he attributed it to an influx of larger fish, rather than better enforcement of the minimum mesh size. He (DHAC member) believed that there was continue use of 2 inch mesh; Department enforcement personnel stated that many nets had been checked but there were no violations for undersize mesh. Apparently 2 1/16 inch multi-strand mesh would pass the measuring test. There was some discussion and some disagreement among industry members in attendance at the meeting as to whether the measuring technique was accurate and/or effective at eliminating the use of 2 inch mesh. There was no resolution on the matter reflected in the notes.

(Recommendations for 1990-91) Industry proposal to reduce all quotas by 30% and increase the minimum mesh size to 2 3/16 inches.

- 1990-91 Season. No changes to mesh size or mesh measurement methods in regulation. A letter dated October 24, 1990 states that "at the October 5, 1990 Fish and Game Commission meeting the Commission chose not to take any action on the proposed herring regulations for the 1990-91 season. <u>Therefore, the existing herring regulations that were in effect for the 1989-90 fishing season shall remain in effect and shall govern the fishery during the 1990-91 season</u>. The Commission chose this course of action because of threatened legal action based on a perceived failure to comply with California Environmental Quality Act (CEQA) requirements as regards the herring fishery."

Notes from the March 21, 1991 DHAC meeting minutes:

(Net measurement and mesh size) "Department enforcement personnel stated that enforcement had difficulty prosecuting cases involving the measuring of gill net mesh using the plastic "credit card" given to permittees. A Department enforcement officer demonstrated a measuring device that he felt would withstand a court challenge because it follows guidelines set forth by the Pennisi decision. He stated that near the end of the season, every net he measured (22) using this device was illegal. He also recommended restricting net to #7 twine and prohibiting the use of multi-strand nets. A Department biologist stated that the method of measuring mesh evolved from the trawl fishery, with four meshes stacked together. He added that the plastic card should work. An industry member reiterated the Department biologist's statement regarding the measuring of four meshes and wondered why the size of mesh was restricted for gill nets and not for round haul nets. Department enforcement personnel noted that the Alameda courts threw out cases involving illegal small mesh measured using the plastic cards. The criteria, bending of the card, were considered subjective." A discussion of multi-strand and single-strand gill nets followed with no resolution to the issue.

(Recommendations for 1991-92) In the July 11, 1990 Pre-Adoption statement, in response to an industry proposal for an increase in the minimum mesh size for gill nets from 2 1/8 inch to 2 3/16 inch, the Department responded that due to a new technique for measuring mesh, instituted prior to the 1989-90 season, which accounted for the elasticity of the net material, and an increase in the average size of the fish landed during the past season, there did not appear to be significant justification or support to increase the minimum mesh size at the present time.

A DHAC member proposed a two-week later opening date, bag limits, and that drift nets be allowed in Humboldt Bay and Crescent City.

- 1991-92 Season. No changes to mesh size or mesh measurement methods in regulation. The closure of the 'Banzai' area to gill nets from November 28 through February 14 is included in the regulations.

Notes from the March 17, 1992 DHAC meeting minutes:

(Net measurement and mesh size) "Department enforcement personnel stated that enforcement intended to look into a different net measuring procedure for next season in order to reduce the use of undersized mesh. The procedure that we are looking at involves the use of a weight and would be similar to the method employed in the State of Alaska." There was a short discussion of this method and the fact that enforcement was unable to make any cases involving mesh size with the current method. Following another lengthy discussion an industry member volunteered to work with enforcement and attempt to find a solution to the problem.

(Recommendations for 1992-93) "Enforcement to investigate potential alternative net measuring procedures."

"Increase the minimum mesh size for gill nets used in the Tomales Bay fishery from 2 inches to 2 1/8 inches." This proposal, along with a reduction in the amount of fishing gear allowed, "will reduce the potential take of younger, smaller fish, while a reduction in the amount of fishing gear will minimize potential disruption of herring schools and spawning activities." The Department and the herring industry agreed on this proposal. (June 4, 1992 Statement of Purpose for Regulatory Action)

- 1992-93 Season. Mesh size regulations: The minimum mesh size in Tomales and Bodega Bays was changed to 2 1/8 inches. No other changes to mesh size or mesh measurement methods in regulation in any other bays.

Notes from the March 16, 1993 DHAC meeting minutes:

(Net measurement and mesh size) Enforcement reviewed the problems associated with the measuring of small mesh gill nets. There was discussion that the courts had indicated that specific standards such as twine size needed to be established. Several industry members noted that it would take at least one year's notice for the manufacturers to supply new nets. The Department Deputy Chief stated that if the minimum mesh size was increased to 2 ¼ then those fishermen using the smallest nets would have to increase the minimum mesh that they used (in order to comply), and although it would resolve the problem it would improve the situation until such time that industry standards could be established and implemented. There was no resolution on this matter reflected in the notes.

(Recommendations for 1993-94) The Department recommended a 26,000 ton baseline spawn escapement as a threshold by which to open and close the fishery, which is equal to 50% of the average escapement value estimated over the 12 year period from the 1980-81 season through the 1991-92 season.

The allowance of beach seine gear in Tomales and Bodega Bays was removed because it was no longer necessary (no more beach seine permittees). (May 28, 1993 Statement of Purpose for Regulatory Action)

⇒ Note: Department staff introduced the proposal to encourage the transfer of round haul permits to the gill net fishery.

- 1993-94 Season. No changes to mesh size or mesh measurement methods in regulation.

Notes from the DHAC Meeting minutes:

There were no comments specific to problems with mesh size or measurement. There was a comment from industry that although the Commission had requested the conversion to an all gill net fishery in 1979, the Commission now consisted of entirely different members and they may not want the conversion. It was reiterated that the Commission had reaffirmed its position in August, 1993 when it directed the Department Deputy Chief, representing the Department, to submit a conversion proposal for consideration in 1994.

A proposal to amend Subsection 163 (b)(2) to provide for the voluntary conversion from round haul gear to gill net hear, followed by a mandatory conversion after October 2, 1998 for all remaining round haul permits was included in the Statement of Purpose for Regulatory Action.

- 1994-95 Season. No changes to mesh size or mesh measurement methods in regulation.

There were no comments specific to problems with mesh size or measurement, and there were no proposed changes to regulations specific to mesh size or measurement.

- 1995-96 Season. No changes to mesh size or mesh measurement methods in regulation.

Notes from the March 14, 1996 DHAC meeting minutes:

(Net measurement and mesh size) "Advisors were informed that the Department will vigorously enforce mesh size regulations, as a result of widespread use of undersized mesh and better net measuring procedures. Department staff spoke of salvaging a herring net, obviously in recent use, from a dumpster outside a herring buying stations. This problem is not one of a very minor decrease under the 2 1/8 minimum side, but of substantially smaller mesh. Advisors asked that the Department settle on a new measuring procedure as soon as possible and the measuring tools be easily obtained by the industry to ensure that they are ordering legal gear."

(Recommendations for 1996-97) Specify the method for measuring mesh size of herring gill nets. Following the receipt of public testimony and discussion of the regulations, the Commission modified subsection 163 (f)(2)(B) to include provisions that nets be measured "when wet after use," and that a three percent tolerance mesh measurement be allowed for the 1996-97 season only in Tomales and San Francisco bays. Language was also added to provide for research on mesh size.

The section language reads: "Length of the mesh shall be the average length of any series of 10 consecutive meshes measured from the inside of the first knot and including the last knot when wet after us; the 10 meshes, when being measured, shall be an integral part of the net as hung and measured perpendicular to the selvages; measurements shall be make by means of a metal tape measure while 10 meshes are suspended vertically from a single peg or nail, under one-pound weight. In Humboldt Bay and Crescent City Harbor, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be les than 22 ½ inches or greater than 25 inches. In Tomales and San Francisco bays, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be less than 21 ¼ inches or greater than 25 inches. For the 1996-97 season only, in Tomales and

San Francisco bays, a 3 percent tolerance will be allowed in the mesh measurement; thus, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be less than 20 5/8 inches or greater than 25 ¾ inches."

There was considerable public comment during the regulatory process regarding the round-haul conversion. The following are some excerpts from the September 13, 1996 Final Statement of Reasons as to the biological benefits of the conversion.

"Two benefits are derived by reducing the catch of two and three-year-old herring: the reproductive potential of the population is increased, and management is improved because year-class strength (i.e., the size of an age group) can be assessed before that year class enters the fishery. The reproductive potential of the population is increased when young fish have the opportunity to spawn. Egg production-per-recruit analysis indicates a substantial increase in population egg production as a result of a shift in recruitment to the fishery (i.e., the age or size at which fish are first catchable by the fishing gear) from age two (age of recruitment to the round haul fishery) to four (age of recruitment to the gill net fishery).

The second improvement that results from reducing the take of two and three-year-old herring is that it allows managers to better assess the size of an incoming year class before it is fished. We don't know the size of a year class until the fish are three years old, because not all two year olds spawn. Round haul gear fishes on each year class for two seasons before the year-class strength is known. Conversion to a gill net only fishery will give managers a one year planning horizon to adjust harvest levels to protect weak year classes."

- 1996-97 Season. Mesh size and measurement regulations: Mesh measurement method implemented with 3 percent tolerance for one year only. Language was added to provide for three permittees to participate in a Department sponsored mesh size study in San Francisco Bay.

Notes from the March 21, 1997 DHAC meeting minutes:

(Net measurement and mesh size) Many members of the DHAC expressed the desire to have the 3 percent tolerance in measurements continue. One of the concerns expressed was that a net's mesh size varied considerably depending on whether it had been soaked recently or pulled hard. Opinion on net mesh size varied considerably; some spoke of the advantages of taking larger fish while others expressed concern over reduced catch rates. Concern was also expressed over the amount of herring roe that occurred on nets and the influence of mesh size on the rate of occurrence.

The Department was asked if this was still a resource question given current enforcement efforts directed toward detecting small mesh nets. In response, Department staff indicated that the goal was still to reduce the take of 2 and 3 year-old fish. Mesh size below that allowed by regulation does negatively affect the age structure of the catch. The discussion ended with general support for keeping the 3 percent tolerance and no resolution on changes to mesh size regulations.

(Recommendations for 1997-98) It was proposed to clarify that when measuring mesh size, the 10 meshes will not include "guard mesh".

- 1997-98 Season. Mesh size and measurement regulations: End of tolerance in mesh measurement; the length of any series of 10 consecutive meshes shall not be less than 21 ¼ meshes or greater than 25 inches. No other changes to mesh size or to mesh measurement methods in regulation.

Notes from the March 23, 1998 DHAC meeting notes, not minutes:

(Net measurement and mesh size) Concern over the lack of tolerance in mesh measurement was expressed by several DHAC members. Some members wanted the three percent tolerance in mesh measurement, some didn't, some members wanted 2 1/8 inch mesh, some didn't; in the end the discussion turned to proposing a mesh size study.

(Recommendations for 1998-99) There were no proposed changes to mesh size or mesh measurement method.

- 1998-99 Season. The round haul conversion was completed. No other changes to mesh size or mesh measurement in regulation.

Notes from the March 23, 1999 DHAC meeting minutes:

(Net measurement and mesh size) There was much discussion around the method of mesh measurement, and in summary, several industry members were felt that the problem in San Francisco Bay was not necessarily with the mesh size, but with the measurement method. Enforcement noted that although 200-250 nets were measured, only four nets were considered to be sufficiently undersized to warrant a citation and net seizure. In Tomales Bay, it was felt that the mesh size was too large. It was requested by that a mesh study be conducted as soon as possible, and it was agreed that fishermen would be included in a study design.

(Recommendations for 1999-2000) Language was proposed to allow four permittees to participate in a Department sponsored mesh size study in Tomales Bay.

- 1999-2000 Season. Mesh size regulations: Four permittees (designated by the department in writing) participating in department-sponsored research on mesh size in Tomales Bay may use gill nets approved by the department with mesh less than 2 1/8 inches.

⇒ Mesh study conducted in San Francisco Bay using 2 1/16 and 2 1/8 inch mesh. Four permittees (three odd, one special ed.) participated in the study using two-paneled nets, half 2 1/16 inch and half 2 1/8 inch mesh. The total catch for the study was 22 tons. The roe percentage was 13 and 14 percent for 2 1/16 and 1 1/8 inch mesh, respectively. A fish count of 91 and 85 per 10 kg sample of 2 1/16 and 2 1/8 inch mesh, respectively, was also recorded. These data, in general, indicate that smaller mesh catch smaller fish and larger mesh catch larger fish. The data collected represented a relatively small time period (six sampling days during a two week period), and a longer term, i.e. subsequent seasons, would be preferable.

Notes from the March 23, 2000 DHAC meeting minutes:

(Net measurement and mesh size) A Tomales Bay DHAC member expressed concern that they were using the wrong mesh size, and that since the increase in mesh size to 2 1/8 inches they have been unable to catch fish. Department staff explained that Department data indicated that Tomales Bay catch consisted of age four and older fish and that this is the management goal of the Department. The Tomales Bay DHAC member felt that 2 inch mesh would be more appropriate. A San Francisco Bay DHAC member expressed concern over the quantity of spawn seen on the gill nets, belly-caught fish and the length of time it now took to catch the quota. He felt that a mesh size reduction to 2 1/8 inches would address these concerns.

(Recommendations for 2000-01) The length of meshes of any gill net used or possessed in the roe fishery in Tomales Bay for the 2000-01 season only shall be no less than 2 inches or greater than 2 ½ inches. The proposed one-year amendment will allow the Department to evaluate the effect of reduced mesh length on the size and age composition of herring caught in 2 inch mesh gill nets. Preliminary aging of Tomales Bay herring suggested that reduced growth of herring in offshore waters and loss of older fish from the spawning population has resulted in a mean length of herring in the commercial catch below the 5-year average. However, the 1995 and 1996 year-classes are well represented and, by number, comprised more than 50 percent of the spawning population this season.

- 2000-01 Season. Mesh size regulations: Fleet-wide mesh size study conducted in Tomales Bay using a minimum 2 inch and maximum 2 ½ inch mesh.

Notes from the March 20, 2001 DHAC meeting minutes:

(Net measurement and mesh size) There was a brief discussion of the mesh size study in San Francisco Bay. Department staff explained that more data was needed in order to consider any further reduction in the mesh size. A DHAC member proposed contracting one of the herring boats to be used exclusively in the study, rather than having to compete with other gill-netters simultaneously, and he suggested increasing the quota for that boat to attract "high-liners". He also suggested that the Department keep a portion of the proceeds from the sale of product from the higher quota and use it to pay for Departmental research costs. The DHAC members supported this idea and one DHAC member volunteered the use of his boat.

(Recommendations for 2001-02) Amend subsection (f)(2)(B) to specify the size of peg or nail used on certified net measuring devices.

- 2001-02 Season. Mesh size and measurement regulations: Continuation of the fleet-wide mesh size study in Tomales Bay. Clarification of the size of peg and weight used in the measurement of mesh was added to Section 163, subsection (f)(2)(B) to read: …while 10 meshes are suspended vertically under one-pound weight, from a stainless steel peg or nail of no more than 5/32 inch in diameter ~~under on-pound weight~~. A provision was also added to subsection (g)(4)(B) to allow ten tons of the fresh fish quota to be transferred to gill net permittees participating in Department sponsored research.

Notes from the March 27, 2002 DHAC meeting minutes:

(Net measurement and mesh size) There was a discussion of re-initiating the mesh size study in San Francisco Bay for the 2002-03 season. A Department biologist stated that no funding was available for the Department to conduct the study and suggested that the industry form a subcommittee to discuss and form a proposal for a collaborative study with the Department. A DHAC member voiced concern that the mesh size being used could be harming the resource by not catching fish efficiently, i.e. causing latent mortality of the squeezed fish through the net and also increasing the fleet's fishing effort and subsequent disturbance of schools. He also questioned the biological rationale for enforcing the 2 1/8 inch mesh size. Department staff explained that the reason for the 2 1/8 inch mesh is to concentrate the fishing effort on herring in the 4-year and older age classes, and reducing the mesh size could increase the number of two and three year old herring in the commercial catches. Another DHAC member questioned why the data from the mesh size study in Tomales Bay could not be extrapolated for San Francisco Bay and Department staff explained that the Tomales Bay fishery was managed separately form the San Francisco Bay and has always had different environmental conditions and concerns. He detailed these differences, emphasizing the importance that the study be specific to San Francisco Bay and that any changes must be based on localized scientific data.

(Recommendations for 2002-03) Revise the individual quota provisions for permittees participating in a mesh size study in San Francisco Bay to 0.5 percent of the sac roe quota for each platoon to which a permittee is assigned, and increase the maximum number of permittees that may participate in a mesh size study in San Francisco Bay from three to six. Continue the provision to transfer ten tons of the fresh fish quota to gill net permittees participating in the Department sponsored research.

- 2002-03 Season. Mesh size regulations: Continuation of the Tomales Bay mesh size study. Subsection (g)(4)(A) was amended to read: …Each gill net permittee (designated by the department in writing) participating in research sponsored by the department shall be assigned an individual quota equal to 0.5 percent of the season gill net quota per assigned platoon, unless provided for pursuant to subsection (g)(4)(B) of these regulations.

Notes from the March 25 and 26, 2003 DHAC meeting minutes:

(Net measurement and mesh size) The Department discussed development of a model based on historical data rather than conducting a mesh size study, as was discussed at the pre-season DHAC meeting. Several DHAC members expressed concern that the use of 2 1/8 inch mesh in San Francisco was harmful to the resource, i.e. fish were squeezing through the nets and possibly injured or killed in the process. One member suggested that a smaller mesh size will help reduce egging on nets while allowing the fishermen to catch the population that exists. The concern of one DHAC member was that the fishery was not managed for economic viability. Several San Francisco Bay DHAC members noted that they used to use the 2 1/16 inch mesh without any problems belly-catching or scaling fish, but the change (in mesh) took place because of regulatory capabilities. Department enforcement personnel clarified that San Francisco fishermen are actually fishing with nets that are 2 3/32 inch which stretch to be 2 1/8 inch when they are wet. A discussion of the regulatory language ensued and it was agreed the two different interpretations could be drawn from the way the regulations are written, and that they should be clarified to eliminate contradiction.

A change to Title 14 was proposed on behalf of Cal Herring, a herring fishermen's association, to reduce the mesh size to 2 1/16 inch mesh measure dry. A previous Department study examining stretch length after 11-12 hours of soaking was cited as a basis for the dry measure. The stretch study found that the nets would stretch form 3/8 inch to 7/8 inch over ten mesh lengths. Later, other DHAC members expressed that a dry mesh measurement is important for the fishery management.

(Recommendations for 2003-04) Due to several concerns, expressed by the Department, regarding the status of the San Francisco Bay stock two quota options were given to the Fish and Game Commission to consider. Option one, the Department preferred option, was a fishery closure (zero quota). Some of the concerns regarding the status of the stock included a shrinking age class structure (fewer age classes represented in the population), a lack of strong recruitment to the fishery, a decline in catch per unit effort, and several years of below average biomass. The Department had been developing a stock assessment model, Coleraine, to evaluate both the status of the stock and the accuracy of the two survey methods used to estimate biomass. The model results indicated that the stock was at approximately twenty percent of its un-fished level. Given the above concerns, and the increasing divergence in both size and trend of the results from the two survey methodologies, the Department sought an independent peer review of the Coleraine model and the survey methodologies. The peer review results confirmed the Coleraine model results and enumerated several suggestions for improving the survey methodologies.

- 2003-04 Season. Continuation of the fleet-wideTomales Bay mesh size study. No other changes to mesh size or measurement in the other bays.

Notes from the March 25 and April 30, 2004 DHAC meeting minutes:

(Net measurement and mesh size) The format of the meeting minutes changed from a summary of the meeting discussions to bulleted comments on various topics. Comments on mesh size by DHAC and industry members included the desire to decrease mesh size to take a broader cross-section of the population, that the current mesh measurement method resulted in citations, a request for the Department to sell "official" standardized measuring devices, use existing data to reduce minimum mesh size to 2 inches, appreciation for implementing and enforcing a larger mesh size, a request for a response as to why the mesh measurement method was changed when the previous method was successful, and a proposal to go to 2 1/16 inch mesh or to 20 5/8 inch over ten meshes measured dry. The Department responded to all requests of the DHAC March 25 meeting in a detailed letter dated April 23, 2004. At the April 30, 2004 DHAC meeting, DHAC representatives were told that they could submit proposals for a mesh study directly to the Commission, or to the Department, for consideration. The Department received one proposal directly from a DHAC representative, and two proposals through the Commission process. In summary, two of the proposals outlined a fleet-wide study reducing the minimum mesh size to 2 1/16 inches measured dry. The third proposal outlined the used of a minimum mesh size of 2 inches measured wet and a change to the method of measurement (i.e. change in peg size).

(Recommendations for 2004-05) Continuation of the fleet-wide Tomales Bay mesh size study. No other changes to mesh size or measurement in the other bays.

Gill net Mesh Size in the California Herring FisherieHistorical Background Notes – Summary Table

Season	Regulation/Change/Why? (if no reference at to why indicated, none was found)
1976-77	The length of meshes of any gill net shall not be less than 2 inches or greater than 2 ½ inches (all bays). The upper limit of 2 ½ inches was specified for districts 11, 12, and 13 in the Fish and Game Code. Industry concern.
1977-80	No information on mesh change in files.
1980-81	Provision for fresh fish mesh size of no more than 1 ¾ inches and distinction between roe fishery and fresh fish fishery.
1981-82	No information on mesh change in files.
1982-83	In Tomales and Bodega Bay the length of the meshes of any gill net used in the roe fishery shall not be less than 2 inches or greater than 2 ½ inches. In all other permit areas the length of the meshes of any gill net used in the roe fishery shall not be less than 2 1/4 inches or greater than 2 ½ inches from November 28 through January 14. On or after such date the Director may, if the established fishing quotas are not filled and such action will not impact the herring resource, authorize the use of 2 1/8 inch or 2 inch minimum mesh for gill nets used in the roe fishery. Industry request.
1983-84	Date change to allow minimum 2 1/8 inch mesh, essentially, for the odd and even platoons in San Francisco Bay. A maximum mesh size was established for the fresh fish fishery. Language was also added on mesh measurement.
1984-85	Regulatory change to allow minimum 2 1/8 inch mesh for the XH fishery in San Francisco Bay, making the mesh size uniform in all areas (Crescent City, Humboldt and San Francisco) other than Tomales and Bodega bays. Decision made as a result of industry questionnaire.
1985-86	Increase in maximum mesh size in the fresh fish fishery to 2 inches. Industry request.
1986-87	Removal of subsection describing method of measurement for gill net mesh. Enforcement proposal.
1987-88	Minimum mesh for Humboldt Bay and Crescent City changed increased to 2 ¼ inches. Industry request.
1988-92	There are no changes to mesh size or mesh measurement methods in regulation. In 1991-92 the 'Banzai' area closure in San Francisco Bay was added to the regulations.
1992-93	The minimum mesh size in Tomales Bay was increased to 2 1/8 inches to reduce the potential take of younger, smaller fish and outer Bodega Bay was closed to fishing. There were no other changes to regulations in other bays. Tomales Bay had been closed to fishing since the 1989-90 season while fishing continued in Bodega Bay during this period.
1993-96	There are no changes to mesh size or mesh measurement methods in regulation.
1996-97	Mesh measurement method implemented with 3 percent tolerance for all herring fisheries in California. Language was added to provide for three permittees to participate in a Department sponsored mesh size study in San Francisco Bay.
1997-98	No tolerance included in mesh measurement; last season of round haul fishery.
1998-99	No changes to mesh size or mesh measurement in regulation.
1999-2000	Language was proposed to allow four permittees to participate in a Department sponsored mesh size study in Tomales Bay.
2000-01	Tomales Bay mesh size study using a minimum mesh of 2 inches. Study was provided to allow the Department to evaluate the use of this mesh length on the current population (shorter length at age) and assess whether increased CPUE could be obtained for the catch and still maintain the Department's management goal of a conservative 10 percent exploitation rate.
2001-02	Continuation of the fleet-wide Tomales Bay mesh size study. Clarification of the size of peg and weight used in the measurement of mesh was added to subsection (f)(2)(B).
2002-03	Continuation of the fleet-wide Tomales Bay mesh size study. Revised the quota designated for the mesh size study and increased the number of study participants from three to six in San Francisco Bay.
2003-04	Continuation of the fleet-wide Tomales Bay mesh size study. Peer review of San Francisco Bay stock and methodology (prior to season).

Appendix M Evaluation of Harvest Control Rules for the Pacific Herring Fishery in San Francisco Bay

While there are four stocks of Pacific Herring (Herring), *Clupea pallasii*, that are currently fished, the San Francisco Bay fishery has supported the majority of participants and landings and during the preparation of this Fishery Management Plan (FMP) it was the only actively fished stock. This fishery has been managed via a quota since its inception during the 1972-73 season, and one of the goals of the FMP process was to develop a Harvest Control Rule (HCR) for use in yearly quota setting.

Selection of a HCR for the San Francisco Bay Herring fishery is a process that requires objective and transparent evaluation of alternative approaches. We have tested a number of candidate HCRs using Management Strategy Evaluation (MSE), a procedure to evaluate the short- and long-term performance of management strategies via closed loop simulation under a range of alternative uncertainty scenarios. The operating model, candidate HCRs, uncertainty scenarios, and performance metrics were developed in consultation with Department of Fish and Wildlife (Department) biologists and a Steering Committee (SC) of stakeholders representing industry and conservation groups.

Initial analysis determined that continued harvest when the Spawning Stock Biomass (SSB) was below 5 to 10 thousand tons (Kt) (5 to 9 thousand metric tons (Kmt)), depending on the scenario examined, hindered the ability of the stock to recover quickly. This suggested the need for a cutoff, defined as a SSB level below which quotas would be zero in order to protect the Herring stock and promote recovery during low stock years. Based on these findings, we examined the effect of different cutoff levels on short- and long-term performance metrics. Above a cutoff of 15 Kt (14 Kmt) there was minimal improvement in the probability of being above the target biomass (80 percent (%) of B_{MSY}) or avoiding a low stock size. As the cutoff SSB increased, there was an increase in the probability of a fishery closure, which was one of the performance metrics chosen based on the economic objectives of the fishery. This suggested that both biomass and economic performance metrics were best met with a cutoff of 15 Kt (14 Kmt).

Prior to beginning the MSE process there was an agreement amongst stakeholders to continue the precautionary management approach that has been pursued by the Department since the early 2000s. This has included setting quotas to achieve harvest rates of no more than 10%. All of the HCRs tested had a maximum harvest rate of 10%. The HCRs that ramped up harvest from 5 to 10% had slightly better biomass outcomes than those that started at 10% right after the cutoff SSB, while having lower yields. Based on these findings the SC recommended the HCR in Figure M-1 (HCR 4 in the analysis presented here) to the Department for use in setting quotas for the San Francisco Bay Herring fishery.

This HCR was found to be robust to a wide variety of sources of uncertainty, including assumptions about the productivity and variability of the stock, the natural mortality rate, the selectivity of the fishing gear relative to the age at first maturity, long term declines in the size at age of Herring, and assumptions about the observation error in the survey. The analysis presented here demonstrates that this HCR is generally able to maintain a greater than 50% probability of the stock being above the target biomass, while minimizing the probability of dropping below a critical threshold.

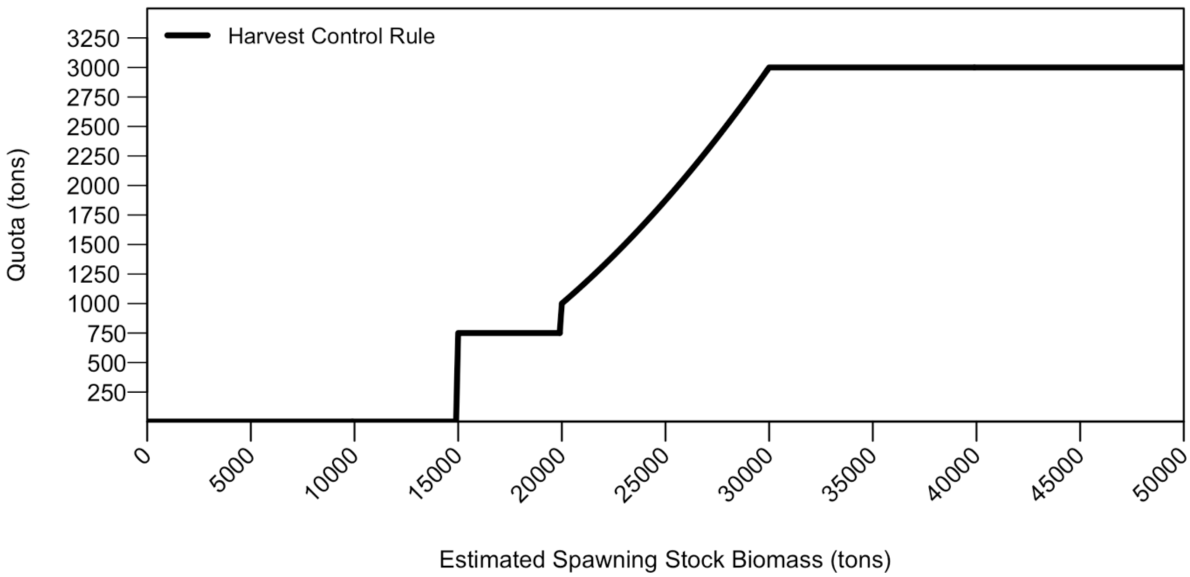


Figure M-1. Agreed on HCR for San Francisco Bay Herring.

Introduction

The Herring stock has historically supported a vibrant and important commercial fishery in San Francisco Bay. This fishery has been managed using an annual quota based on SSB estimates collected by Department biologists. While prior to the development of this FMP fishery management was precautionary due to sound commercial fishery leadership and a high level of collaboration between fleet leaders and the Department, there was an important need to transition the ad hoc annual quota-setting process into a more stable, less costly, and more efficient management system. To address this, one of the major goals of the FMP process was to develop a HCR that reflects precautionary management approaches for use in San Francisco Bay.

The Herring fishery in San Francisco Bay has been managed using a quota since its inception in 1972. Since that time, quotas have been set to achieve desired annual harvest rates (defined as the quota relative to the estimated SSB). However, the method for setting annual quotas was ad hoc, though generally quotas were set to achieve a harvest rate of about 15% of the total estimates SSB prior to 2004, and 10% or less after that time. While harvest rates of 15% may have been sustainable, the practice of merging two separate indices of SSB on an ad hoc basis between 1989-90 and 2002-03 may have led to overfishing. A retrospective analysis suggests that yearly harvest rates may have reached as high as 40% during this time, well over the 20% that is considered sustainable for Herring stocks (Pacific Fisheries Management Council, 1982).

In addition, changing quotas on a yearly basis required a change to Title 14 of the California Code of Regulations (CCR). This required that Department staff go through the full regulatory process each year, including public noticing at Fish and Game Commission (Commission) meetings and development of documents describing the environmental impacts of the recommended quota as well as the alternatives provided on an annual basis to be compliant with the California Environmental Quality Act. The work associated with this regulatory process made it arduous to change the quota each year, and constituted a barrier to a responsive management system. One of the primary goals of the FMP process is to develop a HCR to set quotas as a means of moving the authority to alter quotas to the Department Director.

HCRs provide a pre-determined and structured approach for making annual management decisions based on current stock status, as well as ensuring that those decisions are in line with long-term management objectives. An HCR is just one part of the larger fishery management process that includes yearly data collection, analysis of that data to determine current stock status, and determining the appropriate fishery regulations for the following year. The process for developing and testing HCRs relies on a simulation tool known as MSE, which models every step of the fishery management process in order to understand how each candidate HCR is likely to perform given the current understanding about the fishery. Performance of each HCR is assessed against metrics that reflect management objectives, and are often expressed as the probability, or “risk” of an undesirable outcome. The performance of each candidate HCR is assessed under different assumptions about the dynamics of the system, and tradeoffs between HCRs are examined to determine a preferred HCR.

Though a conservative SSB indicator and harvest rates has been applied to the San Francisco Bay stock since 2004, the observed SSB has exhibited higher variability than was seen during the 1980s, when the stock was considered to be high and stable and observed SSB was consistently greater than 40 Kt (36 Kmt), and frequently in the 60 to 70 Kt (54 to 64 Kmt) range. MSE provides a forum to test these various hypotheses, and to ensure that the HCR chosen for use in management is robust to various potential factors, even if we don’t know which factors may be operating on our stock. The goal of this MSE analysis is to help select an HCR that will maximize the various management objectives for this stock.

Management Strategy Evaluation

MSE involves the construction of simulation model designed to imitate, albeit in a simplified manner, the dynamics of a fish stock, the fishery exploiting it, and the monitoring, assessment, and management framework that is used to manage the fishery. A key aspect of the MSE approach is that the simulation includes the full management cycle: data collection, analysis, and recommendation and application of a management policy which is then fed back into the system and used to update the stock and fleet dynamics in the next time-step (Walters and Martell, 2004). Simulation models with the property of a feedback loop, where the simulated management policy is updated based on the perceived state of the system, are known as 'closed loop' (Walters and Martell, 2004), and are distinct from risk assessment models that are commonly used to evaluate the implications of an unchanging management regulation (Punt, 2015). The main advantage of the closed-loop simulation approach is that it allows direct comparison and evaluation of alternative management procedures against the known state of the system; something that is usually impossible in the real world (Walters and Martell, 2004).

The primary aim of an MSE is to identify the emergent behavior of alternative management strategies, and to describe the various trade-offs that are likely to arise among conflicting management objectives (Punt and others, 2016). Rather than attempt to identify an optimal management approach, an MSE aims to provide decision-makers with the information they require for a rational and defensible decision on the management of the fishery, that balances management objectives and acceptable level of risk (Smith, 1993). Additionally, MSE can be used to develop and test new management strategies, either for a specific fishery or more as generic methods for general application, as well as identify classes of management methods that are unlikely to perform well and thus be generally rejected as candidates for management (Butterworth, 2007).

Stakeholder Engagement

MSE is intended to facilitate a process of decision-making that is deliberate, transparent, and reproducible (that is, independently testable). MSE is not intended to yield a single correct result, but rather to elicit a thoughtful discussion of management objectives that guide the evaluation of different possible management procedures and the inherent trade-offs, benefits, and risks they present. As such, MSE can be a powerful tool for engaging stakeholders and increasing buy in the results of the analysis.

Periodic meetings were held throughout the process with the SC, which was composed of representatives from industry, conservation groups, and Department biologists. During the early meetings, information on the MSE process and the vocabulary used was provided to ensure that all participants had an understanding of the process and felt able to interpret results and participate in discussions. A brainstorming exercise was conducted to develop management objectives for the fishery, and these were narrowed to include only those objectives that were directly influenced by the HCR (rather than another management measure, such as the number of participants in the fleet).

These objectives were converted to a set of quantitative performance metrics, which were tracked during each simulation run. The results of these simulations were presented to the SC for feedback, and were ultimately used in the final decision about which HRC to recommend to the Department.

SC members also participated in the iterative development of the operating model and uncertainty scenarios. For example, an age-structured stock assessment model was commissioned for the San Francisco Bay Herring stock by the Centre for Environment, Fisheries and Aquaculture Science (Cefas). Prior to the completion of the peer review process, an operating model was developed based on that stock assessment model, albeit with a less optimistic stock recruitment curve. Members of the SC expressed concern about some of the assumptions in the operating model, and participated in evaluating whether the simulation model was able to accurately recreate historical conditions. These discussions contributed to which uncertainty scenarios were ultimately considered.

MSE Design and Analysis

This MSE was conducted using the Data Limited Methods Toolkit (DLMtool) package in R (Carruthers and Hordyk, 2017). The DLMtool is an open-source software package designed for conducting MSEs, and is highly customizable. The MSE framework within the DLMtool is comprised of three key components: 1) an operating model that is used to simulate the stock and fleet dynamics, 2) an observation model that simulates the expected imprecision and bias in the fisheries data that are typically observed and used in management, and 3) an assessment and harvest control rule model that uses the simulated fishery data from the operating model to provide management recommendations (a quota). The relevant equations underlying this analysis are provided in Appendix M-A.

Operating Model

In order to simulate a fishery and understand its expected performance when managed under each candidate HCR, it is necessary to build an operating model (OM) that describes the best available information about the biology of the stock and the socioeconomic dynamics that govern fleet behavior. Ideally, the OM is based on a stock assessment that has analyzed historical data to estimate population dynamics that are difficult to measure. The Department, in collaboration with the San Francisco Bay Herring Research Association, commissioned Cefas to complete a stock assessment, with the intent of using that model as the base-case operating model. However, the model had difficulty fitting a few key parameters, and an independent review panel felt that more work was necessary before the model could be considered the best representation of what is known about the San Francisco Bay Herring stock dynamics. Despite the Cefas model not being recommended for use as an operating model, it did represent a great deal of work to analyze the available data for this fishery, and some parameter values were used to inform the OM, especially for parameters like estimates of historical fishing mortality or recruitment deviations. This OM was developed in consultation with Department biologists in an attempt to capture the best available information about the San Francisco Bay Herring stock.

The DLMtool is a stochastic modeling platform, and most input parameters are required to be specified as a range (a minimum and maximum value). The model randomly draws parameter values from a uniform distribution with bounds specified by these input parameters for each simulation. This allows the simulation model to fully incorporate the level of uncertainty associated with each parameter. Some derived parameters in the OM may also vary by year, either randomly or as a gradient, depending on how they are parameterized. For each uncertainty scenario we ran 500 simulations, each with its own set of randomly drawn parameters from the distributions below. All of the parameter distributions and functional forms used in the base model can be viewed the figures in Appendix M-B.

Here we describe the parameters used in the base model. These parameters are used in all scenarios unless otherwise specified (for example, in an uncertainty scenario exploring an alternative selectivity ogive, the selectivity is altered and all other parameters are as described in the base model).

Maximum Age

The maximum age observed for Herring in California is 11 from the Humboldt Bay stock in 1974-75, when the roe fishery for Herring began (Rabin and Barnhart, 1986). The maximum age observed in San Francisco Bay is nine (Spratt, 1981). The maximum age declines with latitude in Herring, and it is likely that few fish live past ten in central California. For this reason, ten was assumed to be the maximum age. There is no plus group in the DLMtool, and all fish die once they are older than the maximum age.

Natural Mortality

There are no direct estimates of the instantaneous natural mortality rate (M) available for California Herring stocks. Based on the observed maximum age, average M is likely to be between 0.45 and 0.6 for California stocks. Initial simulations assumed that M was uniformly distributed between 0.4 and 0.65 (corresponding with value of 0. 53+/- 20%), with the randomly drawn value being static over all ages and all years of each simulation. We then explored the impacts of a number of different assumptions about M in the uncertainty scenarios to ensure that the preferred HCR is robust to these assumptions.

Growth

Length at age was simulated using the von Bertalanffy growth equation. Parameter estimates were derived from fitting a model to length at age data from San Francisco Bay collected between 1984 and 2016. From this model fit, a variance-covariance matrix was generated and this was used to draw correlated sets of Linf, k, and t0 for use in the simulations. In the base model it was assumed that the growth parameters did not vary over time.

The weight-length relationship parameters a and b were estimated from data sampled from the research catch between 1984 and 2016. The units are in millimeters (mm) (length) and short tons (ton) (weight). These parameters are assumed to be known without error and a point value rather than a range is specified for each.

Maturity at Age

There are no direct estimates for maturity at age from California Herring stocks. The values used in the base model were borrowed from Hay (1985) for British Columbia stocks.

Recruitment

Stock recruitment is assumed to follow a Beverton-Holt stock recruitment relationship. The steepness of the stock-recruitment curve is defined as the level of unfished recruitment at 20% of unfished spawning biomass. The steepness value for San Francisco Bay Herring is unknown, and thus a wide range of values was used for this analysis to reflect that uncertainty. We specified a range of 0.49 to 0.86 for the steepness parameter for the base model based on a meta-analysis of steepness for clupeids (Myers and others, 1999). A recent stock assessment for Herring in British Columbia estimated steepness values ranging between 0.58 and 0.89 (Fisheries and Oceans Canada, 2016), with median values in the 0.7 to 0.81 range, which is slightly higher than the range we assumed. However, it is possible that Herring in San Francisco Bay, which are at the lower end of their range, may exhibit lower productivity than Herring in British Columbia.

It was also necessary to specify the magnitude of annual recruitment deviations. Herring demonstrate high variability in annual recruitment deviations. The Cefas stock assessment found that a value of 0.7 maximized the joint log-likelihood, with a 95% confidence interval between 0.55 and 0.95, and we used this range in the base model. The Cefas model showed patterns of autocorrelation in the recruitment residuals, and estimated autocorrelation to be equal to 0.739. For this analysis we assumed that auto-correlation ranged between 0.7 and 0.8 in the base model.

The level of unfished recruitment was chosen to scale historical catches and population sizes to those observed in San Francisco Bay between 1973-74 and 2016-17.

Stock Depletion

The OM requires parameters specifying the current stock depletion (defined as the stock size relative to the unfished stock size, B0) for use in forward simulations. The current depletion for Herring is unknown. The average unfished levels are highly uncertain for stocks such as Herring due to their relatively short lifespan as well as the fact that total biomass is strongly driven by recruitment. In addition, it is likely that shifts from cooler, high productivity regimes to warmer, lower productivity regimes influence the level of unfished biomass the ecosystem can support.

The Coleraine stock assessment model suggested that when the analysis was performed in 2003, the stock was somewhere between 20 and 25% of the 1970s biomass (Observed SSB 2003 = 13 Kt (12 Kmt)). This suggests that the spawning biomass in the early years of the fishery was 50 to 60 Kt (45 to 54 Kmt). Observed SSB estimates over the past 4 yr have ranged from 15 to 18 Kt (14 to 16 Kmt). Following the Coleraine model estimate, it was assumed that this stock size corresponds to a 20 to 30% range for the base model; corresponding with unfished stock sizes of 50 to 90 Kt (45 to 82 Kmt).

Spatial Distribution

The model was assumed to have no spatial structure.

Historical fishing mortality

The DLMtool uses estimates of historical fishing effort rates and an optimized catchability parameter to simulate historical conditions while achieving the current specified depletion range. Yearly fishing mortality rates are specified using a uniform distribution. We used the estimates from the Cefas stock assessment, which estimated fishing mortality rates back to 1992, to inform the range of historical fishing effort sampled for those years. Prior to that, we assumed that given the low quotas in the very early years of the fishery that initial fishing effort was low, but that it ramped up quickly and may have been very high in the late 1970s and 1980s.

The mean trend of fishing effort is sampled, and then log-normally distributed error is added to simulate interannual variability in fishing effort. We assumed that effort varied between 0.03 and 0.012 (the standard deviation of the time series of fishing mortality estimates from the Cefas stock assessment). We assumed no trends in fishing efficiency given that the amount and type of gear is highly regulated in this fishery, and assumed that the parameter governing increases in catchability ranged between -0.1 and 0.1, while the parameter governing the interannual variability in catchability ranged between 0.0 and 0.05.

Selectivity

Historical selectivity was estimated from the yearly size distribution of the catch and converted to selectivity at age. Prior to 1998, both round haul and gill net gears were used, and so slightly more age three fish were selected prior to that time. To capture this change in the historical selectivity we used a yearly age-based selectivity ogive. In the base model the future selectivity was assumed to be the current selectivity. We explore a number of different selectivity assumptions in the uncertainty scenarios.

Observation Error

The HCRs tested depend on an estimate of the total SSB each season. San Francisco Bay Herring has a spawning survey that acts as an index of absolute abundance (Bt). The coefficient of variation of that survey over the last 45 yr has been 0.75. It is unknown how much of this variation is due to process error vs. observation error. In the base model, we assumed that the surveys are relatively precise, with observation error distributed between 0.0 and 0.2. We also assume no directional bias, though it is assumed that the surveys provide an underestimate of the true spawning biomass due to difficulties in sampling the full extent of every spawning event in a timely fashion. We explored these assumptions in the uncertainty scenarios.

Implementation Error

The DLMtool currently assumes that all recommendations (catch limit, size limits, and so forth) from the management procedures are perfectly implemented. This is a reasonable assumption for the commercial sector, where catches are closely monitored to determine when the quota has been reached.

Uncertainty Scenarios

Due to the natural variability exhibited by Herring stocks, there are a number of sources of uncertainty for the San Francisco Bay fishery, despite the fact that it has been intensively monitored since the mid-70s. Some primary sources of uncertainty were identified during the data analysis process to develop an OM for Herring and the Cefas stock assessment review process. We have tried to examine as many sources of uncertainty as possible given the time and budgetary constraints of this project. For each type of uncertainty we define an "uncertainty scenario" as the combination of assumptions regarding the biological, fishery, or management aspects of the system. The uncertainty scenarios are listed in Table M-1.

Table M-1. Uncertainty scenarios presented in this report.			
	Number	Scenario name	Description
Base	1	Base model	Parameters are as described in the OM section of the text
Natural mortality	2	Age-Dependent M	M increases linearly between ages 3 and 10
	3	Variable M	M varies from year to year within each simulation (sd between 0.0 and 0.1)
	4	Sloping M	M increases with each year of the simulation
Selectivity relative to maturity	5	Lower maturity	Assumes San Francisco Bay Herring mature earlier than BC Herring
	6	Selectivity matches maturity	Assumes San Francisco Bay Herring mature earlier than BC Herring, and that all mature fish are vulnerable to the gear
	7	Domed selectivity	Assumes that selectivity is domed shaped
	8	Uniform selectivity	Assumes that all fish age 3-plus are vulnerable to the gear
Productivity	9	Low Productivity	Assumes that steepness is between 0.4 and 0.6
	10	Lower Autocorrelation	Assumes that autocorrelation in recruitment deviations is lower
	11	High Autocorrelation	Assumes that autocorrelation in recruitment deviations is higher
	12	Low Productivity-High Autocorrelation	Assumes that steepness is lower and autocorrelation is higher
Depletion	13	Lower Current Depletion	Assumes that the stock is currently between 0.15 and 0.20% of B0
Decline in size	14	Decreasing length at age	Assumes that there has been a linear decline in the maximum length achieved
Observation error	15	High Error	Assumes the error in the survey estimate ranges between 0.2 and 0.6
	16	Negatively Biased	Assumes the survey routinely underestimates the true SSB
	17	Positively Biased	Assumes the survey routinely overestimates the true SSB

Mortality

In the base model, natural mortality was assumed to be constant for all ages and years. However, there is evidence that M is quite variable. The Cefas stock assessment assumed a fixed estimate of natural mortality (M; 0.53 in the final preferred run, model 19). However, the 95% confidence interval for this estimate was between 0.24 and 0.98. This wide range may be attributable to attempting to fit a single parameter value to describe a process that likely shows considerable temporal variability due to environmental and ecosystem conditions. In addition, estimates of yearly M for British Columbia Herring stocks suggest that M has fluctuated between values of 0.2 to 1 (Fisheries and Oceans Canada, 2016), and may be increasing. Increasing M over time might also be a factor in the lack of older fish observed in the stock between 2004 and 2015. This might also be explained by a recent increase in M as fish get older, as was suggested by the Cefas review panel.

To examine the impacts of these uncertainties we ran uncertainty scenarios with three different formulations of M. In the first one we modeled interannual variability in M by up to 10% (essentially, a random walk). In the second, we modeled mortality that increases linearly from age three, when fish are mature, to age ten. Finally, M was simulated as a time-varying parameter with a consistent increase in M between 0.0 and 2.5% per year (Figure M-2).

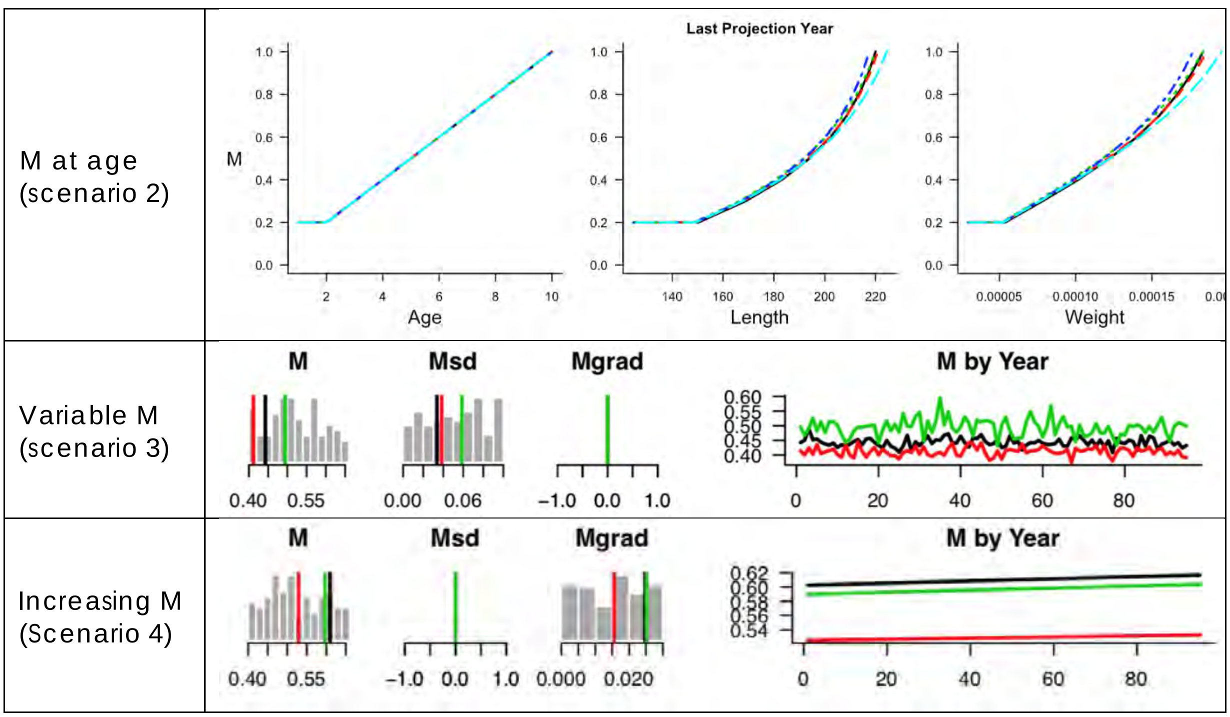


Figure M-2. Parameter distributions associated with scenarios 2, 3, and 4.

Selectivity Relative to Maturity

The sustainability of the stock under various HCRs is bolstered by the assumption that the selectivity of the gill net gear used in the Herring roe fishery allows fish to spawn prior to becoming vulnerable to the fishing gear. However, there are no direct estimates of the age at maturity available for San Francisco Bay Herring, and the best available estimates are borrowed from a study conducted in British Columbia (Hay, 1985). There is a known latitudinal cline in vital rates of Herring stocks along the west coast of North America, and it is possible that San Francisco Bay Herring mature at a younger age than British

Columbia Herring. The assumption of the British Columbia maturity ogive in combination with estimated selectivity ogive means that, in the base simulation, the biomass vulnerable to the fishing gear is only half the total SSB. It is likely that the age at maturity varies from cohort to cohort, and in some years a larger number of age two fish come into the bay and end up in the commercial catch, suggesting that part of why they appear not to be vulnerable to the gear is that many age two fish don't return to spawn. Given the uncertainty in the age at maturity we explored a slightly lower age at maturity (Table M-2), as well as additional selectivity formulations. These uncertainty scenarios are also informative should the selectivity of the gear change in the future.

Table M-2. Maturity and selectivity ogives tested in uncertainty scenarios 5-8.

Age	Current selectivity	Domed shaped	Uniform	British Columbia maturity (Hay, 1985)	Lower age at maturity
1	0.00	0.03	0.05	0.00	0.00
2	0.01	0.25	0.12	0.36	0.60
3	0.19	0.95	1.00	0.94	1.00
4	0.65	1.00	1.00	1.00	1.00
5	1.00	0.79	1.00	1.00	1.00
6	1.00	0.30	1.00	1.00	1.00
7	1.00	0.05	1.00	1.00	1.00
8	1.00	0.05	1.00	1.00	1.00
9	1.00	0.05	1.00	1.00	1.00
10	1.00	0.05	1.00	1.00	1.00

Current Depletion

The current depletion for Herring is unknown. The average unfished biomass are highly uncertain for stocks like Herring due to their relatively short lifespan as well as the fact that total biomass is strongly driven by recruitment. Given the uncertainty surrounding these estimates and the fact that observed SSB was frequently above 60 Kt (54 Kmt) during the 1980s despite heavy fishing pressure, we tested the assumption that the current depletion ranges between 15 and 20% of unfished, which means that SSB0 is between 75 and 120 Kt (68 and 109 Kmt).

Changes in Productivity and Variability of the Stock

Herring are known to be a highly productive stock, with the ability to increase from very low stock sizes when environmental conditions are favorable. However, given their sensitivity to environmental changes, it is also possible that external factors can reduce the productivity of the stock. We explored a low productivity scenario, in which steepness ranges from 0.45 to 0.6. This scenario was intended to simulate recruitment under a warm water conditions or other environmental changes that might contribute to reduce survival of eggs, larvae, or juvenile Herring, and thus lower recruitment to the stock.

We also explored the extent to which autocorrelation and recruitment error impact the performance of our candidate HCRs. We ran a scenario with lower autocorrelation and higher recruitment variability, in which each year's recruitment is less governed by the recruitment in the years before and more by random processes, because the Herring stock has exhibited higher variability since the early 1990s. We also simulated a higher level of autocorrelation, which is similar to cyclical regime changes that can have long-term impacts on Herring. Finally, we combined high auto-recruitment and low productivity in a true "worst case scenario" approach to understand how the HCR would perform under very low productivity conditions (Figure M-3).

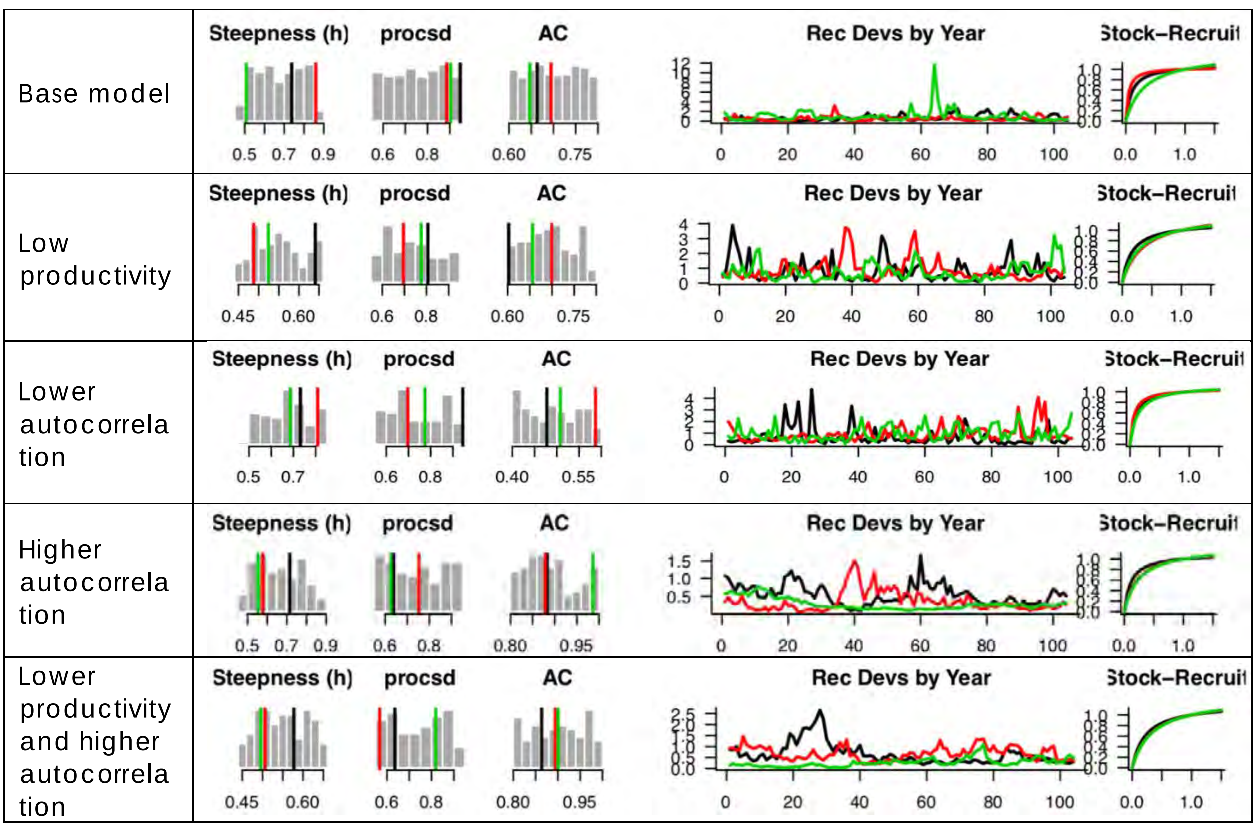


Figure M-3. Parameter distributions associated with Scenarios 1 and 9-12.

Changes in Size at Age

Since the fishery began there has been a decline in the mean length at age of Herring observed in the research catch, particularly in age five and older

Herring (Figure M-4). A similar trend in the mean weight at age as well as the condition index has also been observed, though these metrics have shown more year-to-year variability. Exploitation rates ranged from 0 to 5% since the 2009-10 season, but at the time of development of this FMP, fish had not increased in size, though the age structure demonstrated a return of age 7 and 8 yr old fish in the 2016-17 and 2017-18 seasons. This lack of larger fish caused concern that there has been a fundamental change in the phenotypic expression of length at age in San Francisco Bay Herring, either due to the selective pressures of fishing or to some environmental change. We tested the impact this type of change would have on the performance of our candidate HCRs by modeling a 5 to 10% (uniform distribution) decline in asymptotic length between 1972 and 2016. Growth in the early years of the fishery was estimated from growth values reported by Spratt (1981) in San Francisco Bay, while growth rates in recent years was estimates by fitting a von Bertalanffy growth model to data length at age data from 2009-10 through 2016-17 (Figure M-5).

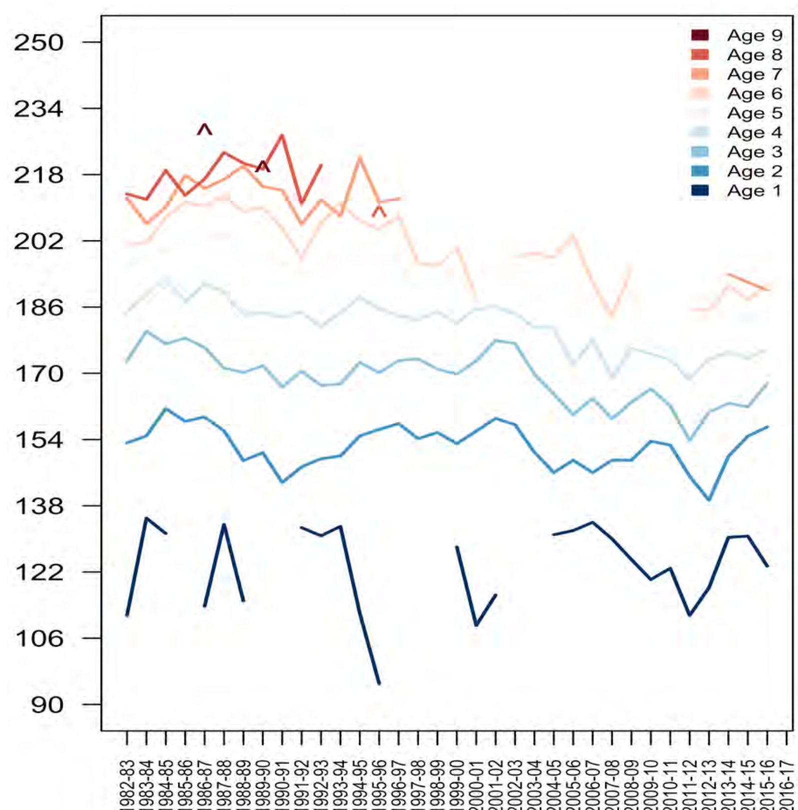


Figure M-4. Mean length at age of San Francisco Bay Herring observed in the research catch between 1982-83 and 2016-17.

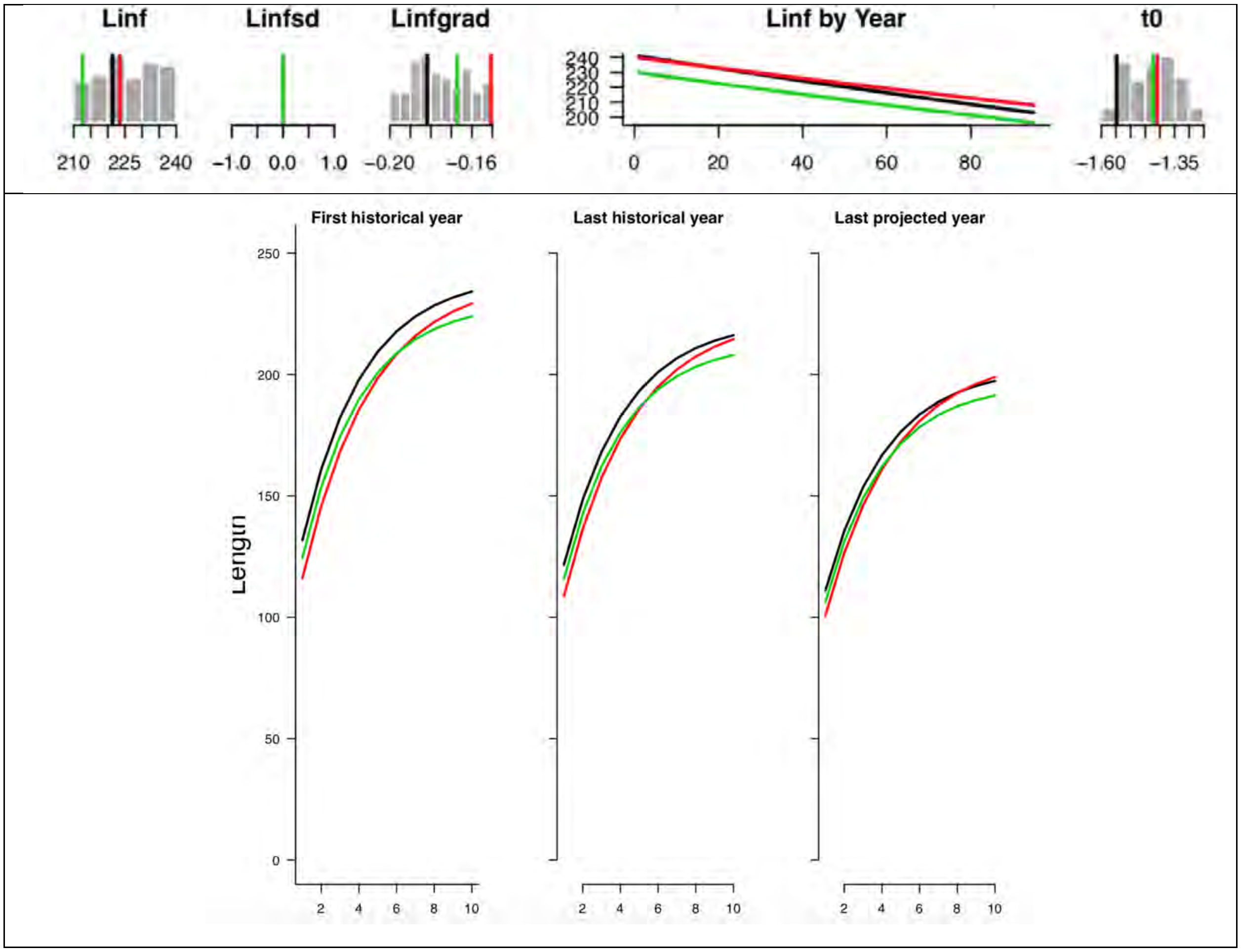


Figure M-5. Sampled growth parameters for decreasing growth (top panel), and the derived length at age for three random samples in the first historical year, last historical year, and last year of the projected simulations.

Observation Error

A 2003 review of the survey methodologies employed by the Department found that the egg deposition survey currently used by the department routinely underestimated the biomass by 10%. The Cefas stock assessment model estimated catchabilities for the spawn deposition surveys that were 0.5 or less in order to fit the available time series of data, suggesting that greater numbers of Herring are present in the stock than come into the bay to spawn or are detected by surveys. While it is unknown by how much, the spawn deposition surveys are generally considered to be conservative estimates due to the likelihood of missed spawning events, and they are made more conservative by the fact that they are treated as an absolute abundance. However, the survey methodology likely adds observation error, and in some years that observation error may be very large, as may have been the case in the 2005-06 season, when a record high SSB estimate greater than 140 Kt (127 Kmt) was produced. Given the uncertainty around the surveys we explored three alternative types of error. The first was a much higher observation error, and the second two include either under or over estimations via the bias parameters (Figure M-6).

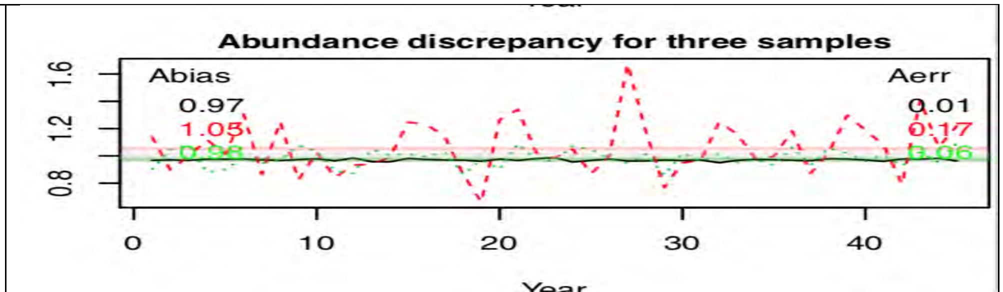
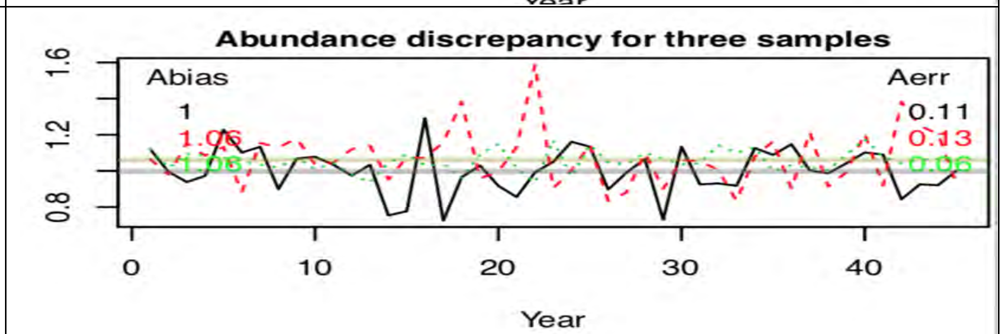
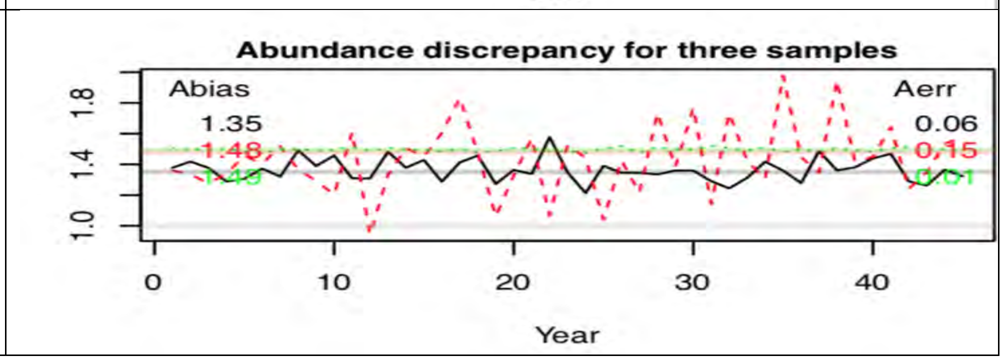
Higher error (Scenario 15)	
Negatively biased (Scenario 16)	
Positively biased (Scenario 17)	

Figure M-6. Randomly drawn sample illustrating different functional forms of observation error.

Candidate HCRs

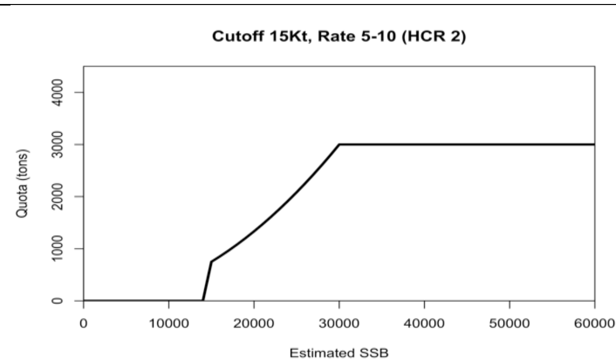
In the early phase of this project we explored a wide range of HCR formulations that met the criteria agreed upon by the SC. These included HCRs with harvest rates that ramped up to meet their target (hockey stick formulation), HCRs with only two harvest rates depending on whether the stock was above or below a certain SSB, and HCRs formulated similarly to those used in the sardine fishery off California, in which the harvest rate is applied to the stock above a minimum escarpment biomass. Initial simulations were conducted over a wide range of biomass cutoffs and harvest rates, and were narrowed down as the simulations provided additional information on the emergent properties of each type of HCR.

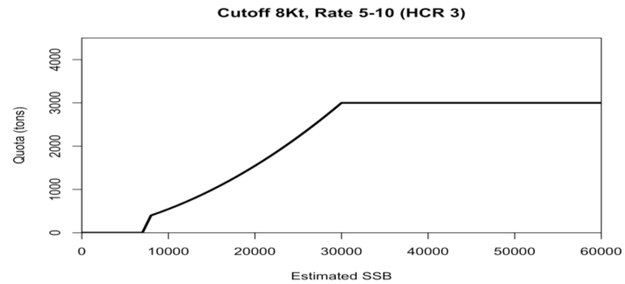
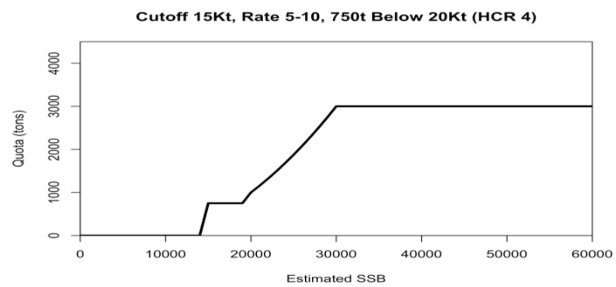
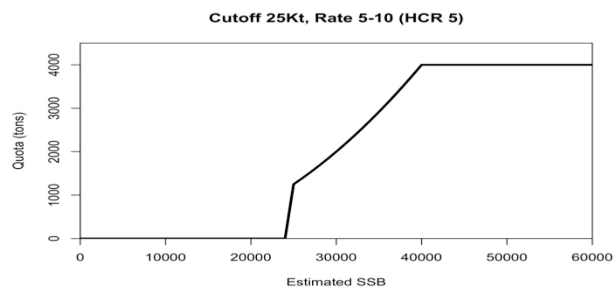
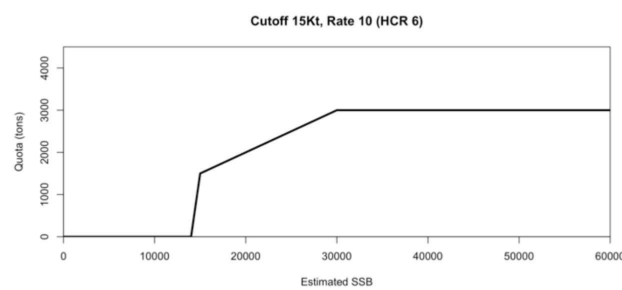
In this analysis we present the results of seven different potential HCRs (Table M-3). HCR 1 is Total Allowable Catch (TAC) that is permanently set to zero, which provides context about the probability of achieving targets and limits even under no harvest, and HCR 7 is fishing at the fishing mortality rate that would provide the maximum sustainable yield (FMSY). HCRs 2 through 6 provide a range of the different HCRs that were considered by the SC at some point. These HCRs are the results multiple iterations of presenting simulation results to the SC, and them providing feedback on changes or additional formulations they would like to see.

Early simulations showed that continuing fishing when the stock was at a very low biomass (less than 8 to 12 Kt, (7 to 11 Kmt) depending on the productivity assumptions) resulted in delayed recovery of the stock to levels around or above BMSY. Additionally, the quotas resulting from harvest rates in the 5 to 10% range (the range preferred by the SC) when the stock was below 8 Kt (7 Kmt) resulted in quotas below the level that is considered the minimum economically viable quota by industry representatives (about 750 tons (681 metric tons)). We have included HCR 2, which has a cutoff at 8 Kt (7 Kmt), to illustrate the relative difference in performance from those HCRs that have higher cutoffs such as 15 Kt (14 Kmt).

HCR 5 has a 25 Kt (23 Kmt) cutoff, as well as a higher maximum quota of 4 Kt (4 Kmt). While early simulations showed that cutoffs above about 12 to 15 Kt (11 to 14 Kmt) provided adequate protection for the Herring stock, this HCR was considered due to concerns about maintaining an adequate forage base for predators of Herring. A recent study has suggested that one-quarter to one-third of biomass should be left unfished to meet predators needs (Cury and others, 2011). The unfished biomass of the San Francisco Bay Herring stock is unknown, and likely fluctuates a great deal based on environmental conditions, but given that the second highest SSB ever observed was 99.4 kt (90.2 Kmt), it was used as a proxy for unfished biomass, and that cutoffs higher than 15 Kt (14 Kmt) should be considered.

Table M-3. The Harvest Control Rules presented in this document. Note that HCRs 1 and 7 are included for reference only, because it is useful to compare the performance of other HCRs relative to no fishing or fishing under Maximum Sustainable Yield (MSY).

HCR number	HCR description	HCR graph
1	No Fishing (quota is always zero). Included for reference only.	No Visual – Quota is always zero
2	Quota is zero when biomass is below 15Kt. When SSB is between 15Kt and 30kt the harvest rate ramps up linearly from 5-10%. When SSB is >30Kt the quota is 3,000t.	

3	Quota is zero when biomass is below 8Kt. When SSB is between 8Kt and 30kt the harvest rate ramps up linearly from 5-10%. When SSB is >30Kt the quota is 3,000t.	
4	Quota is zero when biomass is below 15Kt. Quota is 750t when SSB is between 15Kt and 20Kt. When SSB is between 20Kt and 30kt the harvest rate ramps up linearly from 5-10%. When SSB is >30Kt the quota is 3,000t.	
5	Quota is zero when biomass is below 25Kt. When SSB is between 25Kt and 40kt the harvest rate ramps up linearly from 5-10%. When SSB is >40Kt the quota is 4,000t	
6	Quota is zero when biomass is below 15Kt. When SSB is 15Kt or more the harvest rate is 10% or 3,000t, whichever is lesser.	
7	The harvest rate is FMSY, and is included only for reference	No Visual – FMSY varies by scenario

We consider three different HCRs with cutoffs at 15 Kt (14 Kmt). HCR 3 ramps up harvest rates linearly from 5% at 15 Kt (14 Kmt) to 10% at 30 Kt (27 Kmt). HCR 4 is similar to HCR 3, but between 15 Kt and 20 Kt (14 to 18 Kmt) quotas are static, and set to 750 tons (681 metric tons). This static quota at biomass estimates between 15 Kt and 20 Kt (14 to 18 Kmt) was a feature the SC asked to test as a compromise in an attempt to balance concern about the effect of 5-plus % harvests below 20 Kt (18 Kmt) would have on predators of Herring and the effect of a 20 Kt (18 Kmt) or higher cutoff would have on the fishing industry. HCR 6 has a 15 Kt (14 Kmt) cutoff, and then a 10% harvest rate is applied until the SSB is 30 Kt (27 Kmt). This HCR was included to provide an understanding of how harvest rates as high as 10% (which was recommended as a harvest rate that would allow for rebuilding by the 2003 review panel) would impact the San Francisco Bay Herring stock. This is useful because the proposed HCR framework allows increased harvest rates up to 10% when ecological indicators suggest that forage conditions in the region are healthy, and it is necessary to understand the implications that has for the Herring stock.

HCRs 2, 3, 4, and 6 have with a maximum quota of 3,000 tons, (2,722 metric tons) a feature that was agreed to by the SC. This maximum quota is based in part on the capacity of the fleet once it reaches the fishing vessel cap being proposed as part of this FMP of 30 vessels, each of which are expected to average up to 100 tons (91 metric tons) per season. This cap also leaves additional forage for Herring predators in years when the Herring stock is large. In boom years, Herring may experience greater predation because of its increased availability.

Developing Performance Metrics

It is necessary to define performance metrics in order to compare the relative performance of alternative HCRs. These performance metrics should reflect the management objectives for the fishery, as well as any existing sustainability mandates from the managing agency. The Marine Life Management Act (MLMA), which is the basis for fishery management in California, list the following objectives for the management of California fish stocks:

> *The fishery is conducted sustainably so that long-term health of the resource is not sacrificed in favor of short-term benefits. In the case of a fishery managed on the basis of maximum sustainable yield, management shall have optimum yield as its objective (FGC §7056a)*
>
> *Depressed fisheries are rebuilt to the highest sustainable yields consistent with environmental and habitat conditions (FGC §7056c)*

This provides a mandate for sustainable management, but does not define "sustainability" in terms of biomass targets or limits, nor does it define a risk tolerance for achieving targets or avoiding limits. In the absence of any quantitative mandates we worked with Department biologists and the SC to define management objectives and to develop quantitative performance metrics around those management objectives. This discussion recognized that different stakeholders may have different objectives, or may weight objectives differently. We also provided information on the definitions of target and limit thresholds used by other management agencies, as well as simulation results of the projected stock performance under no fishing as well as fishing at MSY to help provide context for the discussion. Table M-4 shows the agreed upon management objectives for San Francisco Bay Herring, as well as the performance metrics associated with each objective.

Table M-4. Management objectives and corresponding performance metrics for San Francisco Bay Herring.	
Management objective	Performance metric tracked
Maintain the stock at healthy long-term biomass	Probability that the stock is greater than 80% BMSY
Minimize the number of years the stock is in a depressed state	Probability that the stock is less than10% of B0
Maximize catch to the extent possible	Average Annual Catch
Minimize variability in yearly quotas	Average Annual Variation in Catch
Minimize the number of fishery closures (years where the quota is zero)	Percent of Years the HCR recommends a quota of zero

Assessing Tradeoffs

There are generally two accepted methods for evaluating the results of a MSE and choosing a preferred HCR. The first, known as satisficing, involves specifying minimum performance standards for all (or a subset) of the performance measures and only considering management strategies that satisfy those standards (Punt, 2015). The second, known as trading-off, acknowledges that any minimum performance standards will always be somewhat arbitrary, and that decision-makers should attempt to find management strategies that achieve the best balance among performance measures (and hence objectives). For this analysis we recommended that the SC use a combined approach, in which minimum performance thresholds are used only to eliminate methods that are entirely unacceptable to all stakeholders, and then to examine the trade-offs in the remaining methods to identify those that best meet the management objectives. For example, any HCR that resulted in high probabilities of being below 10% of B0 were universally unacceptable to all participants and were excluded.

Results

This section summarizes the results of a subset of the HCRs that were considered over the course of the FMP development process. Based on the results presented here, as well as additional preliminary analysis, the SC agreed that HCR 4, with a 15 Kt (14 Kmt) cutoff, a 750 ton (681 metric tons) quota between 15 Kt and 20 Kt (14 and 18 Kmt), and a harvest rate that increased from 5 to 10% between 20 Kt and 30 Kt (18 and 27 Kmt) was their preferred HCR, and recommended that the Department adopt it for use in Herring management. In the following results, we will refer to HCR 4 as the “agreed on” HCR.

For each uncertainty scenario we tracked the performance of each HCR. Figure M-7 shows boxplots of each performance metric. The probability of being above the biomass target and limit during the last 10 yr period of this analysis are shown. By looking at the last ten years, it is possible to see the performance of each HCR without the impacts of the current conditions.

Each of the HCRs with 15 Kt (14 Kmt) cutoffs have a 96% probability of being above 10% of the unfished biomass (B0) in the last years analyzed. A 25 Kt (23 Kmt) cutoff only increases that probability by 1%, while the HCR with an 8 Kt (7 Kmt) cutoff has a 94% chance of achieving this metric.

All of the HCRs have a greater than 50% probability of being above the target biomass (80% of B_{MSY}) in the last 10 yr. The HCR with an 8 Kt (7 Kmt) cutoff has a 55% probability of being above the target. The conservative features of this HCR, including the 15 Kt (14 Kmt) cutoff, a harvest rate that ramps up to 10% rather than starting at 10%, and the slightly target, in contrast to the agreed on HCR, which has a 60% probability of reduced harvest between 15 and 20 Kt (14 and 18 Kmt) contribute to the higher performance. A 25 Kt (23 Kmt) cutoff provides additional biomass benefits and has a 64% probability of being above the target. Note that, due to the inherent variation in the system, the No Fishing reference HCR only results in a 67% of being above the target biomass. None of the HCRs (other than the FMSY HCR) indicate that there is any likelihood of overfishing.

The average catch at in the short term (first 10 yr of the simulation) at FMSY is just over 3,700 tons (3,358 metric tons) under the base model assumptions. This is less than the average historical catch that has occurred in the fishery, which is 4 Kt (4 Kmt). The HCR with a 25 Kt (23 Kmt) cutoff has the lowest average catch despite having a higher maximum quota (4 Kt) (4 Kmt) than the other HCRs, which have a maximum quota of 3 Kt (3 Kmt). This low average catch is due to the high number of years that the biomass is below the cutoff, resulting in fishery closures.

The agreed on HCR has an average catch of 1,257 tons (1,141 metric tons). This is slightly less than the HCR that begins fishing at 5% above 15 Kt (14 Kmt). Both the HCR with the 8 Kt (7 Kmt) cutoff and the HCR with a 15 Kt (14 Kmt) cutoff but initial harvest at 10% have average catches that are in the 1,500 tons (1,361 metric tons) range. The average catches increase for the long-term projection (last 10 yr of the simulation). Catches are inversely related to variation in yield, which is higher under those HCRs that have lower average yield, and vice versa. This is due to closures during years when the stock is below the cutoff.

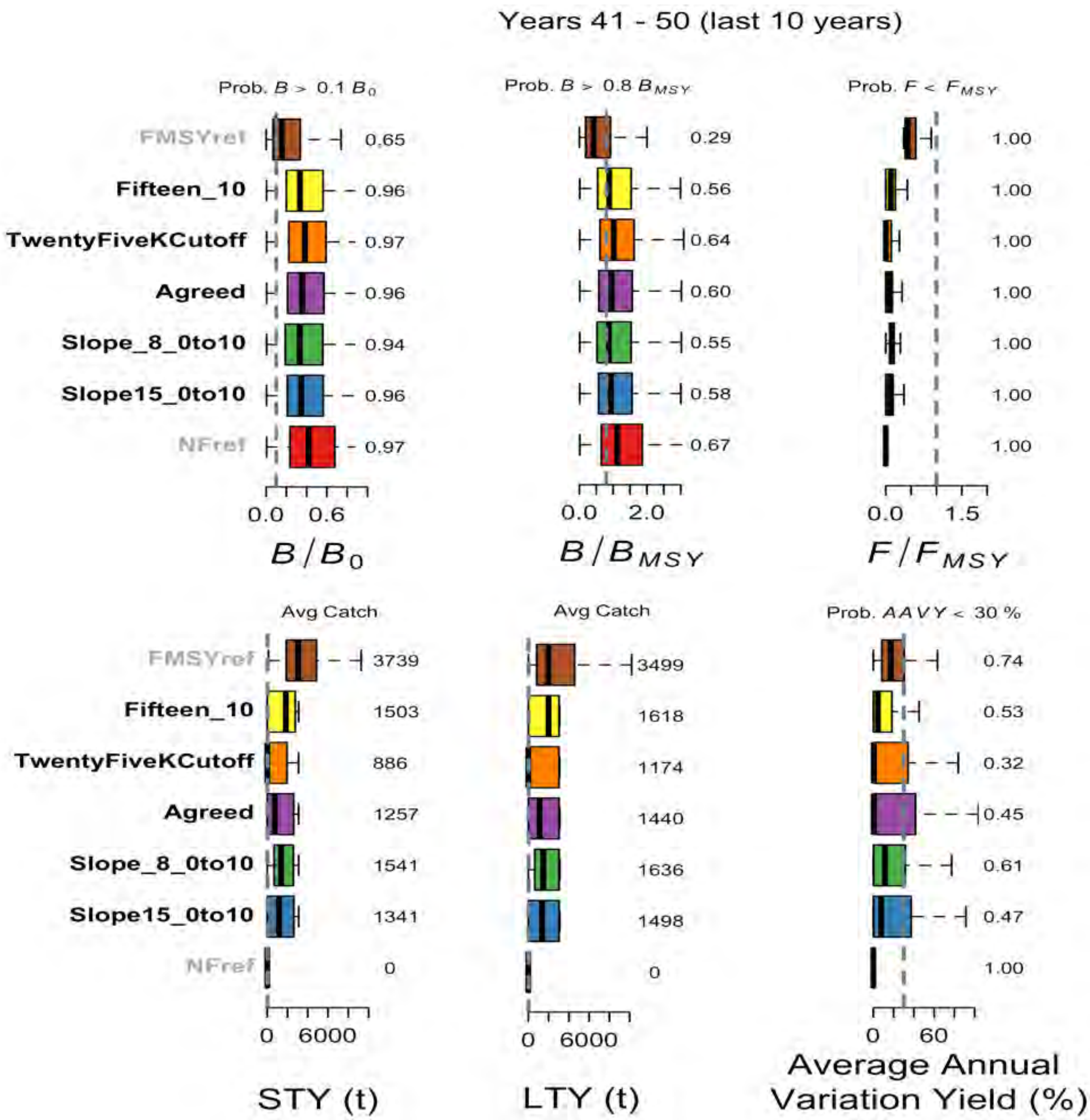


Figure M-7. Boxplots of performance metrics under the base model assumptions. The vertical dashed lines represent performance matrix thresholds.

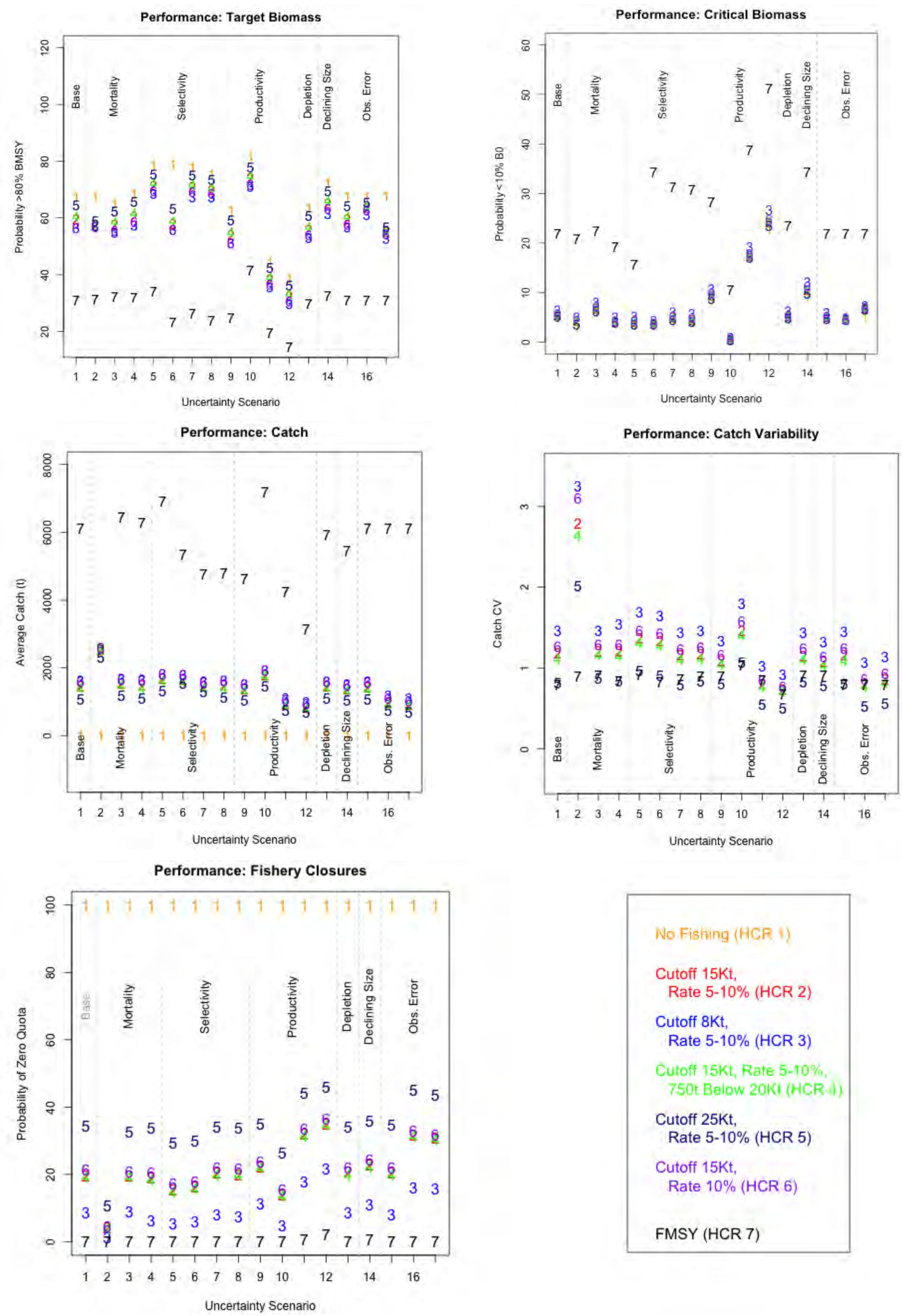


Figure M-8. Performance metrics across all 17 uncertainty scenarios.

Figure M-8 shows the probability of achieving the target biomass across all years and simulations of all 17 uncertainty scenarios. The No Fishing HCR (HCR 1) provides context for the highest possible probability of achieving the biomass target under the assumptions in each uncertainty scenario. The assumptions in each uncertainty scenario change the dynamics of the stock, sometimes in fundamental ways, and so the probability of being above the target (and BMSY itself) is different for each scenario over the 50 yr projection. The exceptions are scenarios 15 through 17, in which only the observation error is different, and so the behavior under HCRs 1 and 7 (which do not depend on the estimate of SSB) are identical to that in scenario 1.

The various mortality scenarios (2 to 4) all increase the natural mortality in different ways. Increasing M with age results in higher catches and lower probabilities of closures across the board, because the higher rate of mortality means that the stock needed to be more productive to achieve the specified depletion at that mortality level. Variable M (scenario 3) resulted in a slightly lower productivity in the stock, and thus the probability of achieving the target biomass was slightly lower across the HCRs considered, as opposed to the slightly higher the probability in this scenario of being under 10% of B0. Increasing M across the years of the scenario had minimal impact on the performance of the HCRs under consideration, though it did increase the variability of that catch.

Lowering the age at maturity while keeping the selectivity curve the same, increases both the probability of being above BMSY under no fishing and average catch at FMSY due to the higher productivity level of the stock that came with increased egg production. Lowering the age at maturity while simultaneously decreasing the selectivity so that all mature fish were vulnerable to the fishing gear means that fishing, even under conservative HCRs, has a higher impact on the stock. However, even with a greater percentage of the spawning stock vulnerable to the fishing gear, the HCRs are able to maintain >50% probability of being above the target. In Scenarios 7 and 8, where the gear selectivity is either domed or uniform above age 3, a smaller percentage of the stock is vulnerable to the fishing gear than in scenario 5.

The assumptions about productivity and variability of the stock have some of the greatest impacts on the performance of the HCRs under consideration. Under the assumption of lower productivity (scenario 9), the stock is less likely overall to be above the target biomass and has a lower probability of being above 10% of B0. However, while the agreed on HCR is able to keep this probability below 10%, HCR 3, with a cutoff of 8 Kt (7 Kmt), surpasses this bench mark under this scenario. In Scenario 10 the variability in the stock is increased and this makes the stock more productive, because of the reduced autocorrelation the stock is more able to bounce back from low stock sizes. Catches are higher and probability of closures are lower under all HCRs in this scenario. Scenarios 11 and 12, in which autocorrelation is increased and, in

Scenario 12, combined with an assumption of low productivity, are very detrimental to the stock. Increased autocorrelation means that periods of lower stock size and a resulting decrease in recruitment reverberate by reducing the productivity of many year classes. Under these scenarios, even the No Fishing Scenario has a greater than 10% probability of being below the 10% of B0. However, the HCRs are able to minimize the impacts of fishing on the stock under those conditions, and keep the probability of the stock falling below this critical biomass threshold to within 2% of the unfished probability. This protection comes at a cost, however, and the probability of closures is very high due to the cutoffs prescribed by the HCRs.

A declining size at age is also detrimental to the long-term productivity of the stock, and results in a 10% probability of the SSB being below 10% B0 even without fishing. This decline in the total length affects the weight of the fish, which affects both the spawning output of the stock and the total biomass. The result is a long-term decline in biomass even without fishing, such that the stock cannot reach its initial "unfished" conditions again. As in the low productivity scenarios, the HCRs tested are able to mitigate biomass impacts under this scenario.

Positive bias in the observation error results in lower probabilities of achieving the target biomass, and higher probabilities of being below 10% of B0. However, we assumed that biases ranged from 30 to 50% above or below the additional survey error, and so a strong directional trend was not always evident in the simulation results. The effects of positive bias was in part lessened by the fact that the vulnerable biomass is only a portion of the total SSB (approximately half). Additionally, the error in this parameter is added to the many other sources of error in these simulations, and so the impacts on the HCR performance generally were not as strong as might otherwise be expected. Given that we generally assume that spawn deposition surveys underestimate the true biomass, the biggest impact of this kind of bias is to the fleet, via reduced catches and increased closures.

Conclusion

These results support the SC's recommendation that the Department use HCR 4 for setting quotas for San Francisco Bay Herring. These simulations were designed to test how robust the agreed upon HCR is to a number of different assumptions about the dynamics of the San Francisco Bay fishery. Many of the uncertainty scenarios were chosen because, under the assumptions within each, the long-term productivity or maximum achievable biomass of the stock decreased, and we wanted to be sure that the HCR would be robust under those conditions. As such, the selection of these scenarios can be thought of as trying to find various "worst case scenarios" that still seem reasonably plausible given what we know about the stock. These scenarios allowed us to understand the likely performance of the HCR should these factors influence the San Francisco Bay Herring stock, either now or at some point during the future.

However, we caution readers from interpreting these results, specifically the average catch or percent closures under these various assumptions, as the actual results that will occur under this HCR. Instead, these results demonstrate that, should the productivity of the San Francisco Bay Herring stock be reduced in these ways, the agreed on HCR can detect the reduction in SSB and adjust harvest rates to safe levels to achieve the two primary stock sustainability objectives, namely, maintaining biomass that has a >50% chance of being above 80% of BMSY, and minimizing the chance of the SSB dropping below 10% of B0 over the next 50 years.

Even with this caution, there may be alarm that closure rates around 20% were common in the scenarios modeled under the agreed on HCR. At first glance there appears to be a strong departure from past dynamics. However, since 1992 the SSB, as estimated from the spawn deposition survey plus the catch (without the hydro-acoustic surveys between 1989 and 2003), has dropped below 15 Kt (14 Kmt) 11 times, and was continuously below this threshold between the 1997-98 and 2002-03 seasons. The simulation results presented here suggest that, had the fishery been closed during that time, the stock may have recovered more quickly.

Like all modeling exercise, this one has a number of limitations. This model does not account for the impact of recreational removals. The magnitude of the recreational catch is unknown, and there is no information with which to parameterize the additional fishing effort, or the effects of a different selectivity for this sector of the fishery. Recreational catch is assumed to be a small fraction of the total removals in most years, because Herring are only available to fishers sporadically, when spawning events occur very near to shore in populated areas. However, there are anecdotal reports suggest that recreational fishing effort has increased in recent year, and recreational removals could have a larger impact on the stock than originally thought.

Another potential source of implementation error that was not considered in this MSE is reduced attainment of the quota in some years. This can be due to a variety of factors, including market conditions, the timing and location of spawns relative to the fishing season and grounds. This analysis assumed that the entire quota was taken in each year, which may be an overestimate of future catches.

Appendix M-A: Operating Model Dynamics

The Operating Model of the DLMtool is a spatial, age-structured operating model that simulates the interaction between a fish population and a fishing fleet.

M-A.1. Conventions

A wide range of parameters and variables are allowed to vary among simulations (e.g., *M*, growth rate, recruitment compensation). All parameters which are random variables that are sampled across simulations are denoted with a tilde (e.g., $\tilde{\sigma}$). Hence, each parameter or variable denoted with a tilde represents a sample from a distribution. For example, the symbol $\tilde{\sigma}$ represents $\tilde{\sigma}_i \sim f(\theta)$ which is the sample of the parameter $\tilde{\sigma}$ corresponding with the ith simulation, drawn from a distribution function *f*(), from the operating model parameters θ. By default these are drawn from uniform distributions unless stated otherwise.

In some cases parameters and variables are derived by numerical optimization. The notation *opt* is used to represent optimizing a parameter *p*, to obtain the objective Δ with respect to existing parameters and variables *θ*: *p* = *opt*(Δ | *θ*). For example $q = opt(\tilde{D}|E, \tilde{M}, \tilde{R}_0)$ represents optimization of the catchability *q* in order to obtain depletion $\tilde{D}$ given fishing effort *E*, natural mortality rate $\tilde{M}$ and unfished recruitment $\tilde{R}_0$ (where $\tilde{D}$, $\tilde{M}$ and $\tilde{R}_0$ are all user defined and drawn from distributions).

Management strategy evaluation has two phases: 1) an historical 'spool-up' phase where data are generated and dynamics produced that create current conditions (fishing from 1972 to 2016), and 2) a projection phase where MPs are tested in closed-loop simulation (a 50 yr projection from 2017 to 2066). The last historical year (2016) is referred to as the 'current year' *c*, in this appendix.

M-A.2. Population dynamics

An age-structured model was used to simulate population and fishery dynamics. Numbers of individuals *N* in consecutive years *y* are calculated from those from the previous year and age class *a*, subject to the total instantaneous mortality rate *Z* (there is no 'plus group' and individuals greater than maximum model age n_a are assumed to die):

1. $\mathrm{Ny}+1,\mathrm{a}+1=\sum \mathrm{N}_{\mathrm{y,a,k}}\,\mathrm{e}^{-\mathrm{Z}_{\mathrm{y,a,k}}}$

Total mortality rate *Z* is the sum of natural mortality (*M*) and fishing mortality (*F*) rates:

2. $Z_{y,a,r}=M_{y,a}+F_{y,a,r}$

Fishing mortality rate (*F*) calculations are included in section M-A.3. below. Natural mortality rate can vary among ages and years and is calculated:

3. $My,a=\bar{M}\left(1+\frac{\tilde{\theta}_M}{100}\right)^{y-c}+\varepsilon_{M,y}$

where $\bar{M}$ is the mean natural mortality rate of mature individuals in the current year and ages, $\tilde{\theta}_M$is the percentage annual increase in *M* over years, n_y is the number of historical years, and $\varepsilon_{M,y}$ is an annual log-normal deviation (Table A.1.).

This parameterization of *M* expressed in Equation 3 is one of the features of the DLMtool. It deliberately allows users the flexibility to include any level of detail in their specification of *M*. Users can only specify mean *M* of mature fish or include any or all of the additional features where appropriate. In uncertainty scenarios where certain parameters are not specified these features are disabled. In addition, it is possible to pass a customized matrix of *M* to the population dynamics model that has dimensions for time and age. Using this feature we also ran a simulation with M increasing by linearly from age 3 to age 10, as was recommended by the Cefas review panel:

4. $Ma=\begin{cases}0.2 & 1\le a\ \le 2\\ a*0.1 & 3\le a\le 10\end{cases}$

By default, DLMtool models growth according to von Bertalanffy model:

5. $Ly,a=L_{y,\infty}\left(1-\exp(-\kappa_y(a-t_0)\right))$

where κ_y is the growth rate, $L_{y,\infty}$ is the maximum length and t_0 is the theoretical age where length is zero. The growth rate and maximum length parameters have year subscripts because, similarly to *M*, these can vary according to slope parameters.

6. $L_{y,\infty}=\bar{L}\left(1+\frac{\tilde{\theta}_L}{100}\right)^{y-c}+\varepsilon_{L,y}$

7. $\kappa_y = \bar{\kappa}\left(1 + \frac{\tilde{\theta}_\kappa}{100}\right)^{y-c} + \varepsilon_{\kappa,y}$

Maturity (m_a) was assumed to be age dependent, and was borrowed from values estimated by Hay (1985) in British Columbia. There are no estimates of the age at maturity for any California Herring stocks, but Herring in San Francisco Bay are thought to begin to mature at age 2 and are mature by age 3. Given the latitudinal cline observed in Herring vital rates, San Francisco Bay Herring may mature earlier than Herring in BC, and so an alternate maturity ogive was explored in uncertainty Scenarios 5 and 6.

The numbers of individuals recruited to the first age group $N_{y,a=1}$ in each year *y* is calculated using a Beverton-Holt stock-recruitment relationship with log-normal recruitment deviations $\varepsilon_{R,y}$:

8. $N_{y+1,a=1} = \varepsilon_{R,y} \frac{4\tilde{h}R_0S_y}{S_0(1-\tilde{h})+(5\tilde{h}-1)S_y}$

, and numbers at age *N*:

9. $S_{y,r} = \sum_{a=1}^{n_a} m_a W_a N_{y,a}$

and the density-dependence parameter β is given by:

10. $\beta R = \frac{4\ ln(5\tilde{h})}{5\ S_0}$

The steepness (recruitment compensation) parameter $\tilde{h}$ is sampled from a uniform distribution. Unfished spawning biomass S_0 is calculated from unfished recruitment $\tilde{R}_0$ and survival to age *a*:

11. $S0 = \sum_{a=1}^{n_a} m_a\ W_a\ \tilde{R}_0\ e^{\sum_{i=1}^{a} M_{1,i}}$

Weight-at-age W_a, is assumed to be related to length by:

where the spawning biomass *S* in a given year is the summation over ages of the maturity at age *m*, weight at age *W*

12. $Wy,a = \beta_W\ {L_{y,a}}^{\alpha_W}$

Log-normal recruitment deviations ε_R include both error and temporal autocorrelation. A series of initial error terms are sampled from a log-normal distribution with mean 1 and standard deviation $\tilde{\sigma}_R$:

13. $\dot{\varepsilon}_{R,y} \sim LN(1, \tilde{\sigma}_R)$

To these initial error terms, temporal autocorrelation θ_{AC} is added:

14. $\hat{\varepsilon}_{R,y} = \tilde{\theta}_{AC}\ \dot{\varepsilon}_{R,y-1} + \dot{\varepsilon}_{R,y}\sqrt{\left(1 - {\tilde{\theta}_{AC}}^2\right)}$

Initial numbers at age (first historical year) were calculated according to unfished recruitment $\tilde{R}_0$, log-normal recruitment deviations ε_R the equilibrium fraction of the stock under unfished conditions.

15. $N_{1,a,r} = \tilde{R}_0 \; e^{\sum_{i=1}^{a} M_{1,i}} \; \varepsilon_{R,y-a}$

Table M-A-1. Sampled parameters controlling variability in stock dynamics			
Symbol	Description	Default distribution	Sampled parameter
$\varepsilon_{M,y}$	Inter-annual variability in natural mortality rate	$\varepsilon_{M,y} \sim dlnorm(1, \tilde{\sigma}_M)$	$\tilde{\sigma}_M$
$\varepsilon_{L,y}$	Inter-annual variability in von Bertalanffy growth rate	$\varepsilon_{\kappa,y} \sim dlnorm(1, \tilde{\sigma}_\kappa)$	$\tilde{\sigma}_\kappa$
$\varepsilon_{\kappa,y}$	Inter-annual variability in maximum length	$\varepsilon_{L,y} \sim dlnorm(1, \tilde{\sigma}_L)$	$\tilde{\sigma}_L$
$\varepsilon_{R,y}$	Inter-annual variability in recruitment	$\dot{\varepsilon}_{R,y} \sim LN(1, \tilde{\sigma}_R)$	$\tilde{\sigma}_R$
	Temporal autocorrelation in recruitment	$\hat{\varepsilon}_{R,y} = \tilde{\theta}_{AC} \; \dot{\varepsilon}_{R,y-1} + \dot{\varepsilon}_{R,y}\sqrt{\left(1 - \tilde{\theta}_{AC}{}^{2}\right)}$	$\tilde{\theta}_{AC}$
	Period (wavelength) of cyclical recruitment	$\varepsilon_{R,y} = \hat{\varepsilon}_{R,y}\left(1 + \sin\left(\frac{\tilde{U}n_y + 2y\pi}{\tilde{\theta}_{period}}\right)\tilde{\theta}_{amplitude}\right)$	$\tilde{\theta}_{period}$
	Amplitude of cyclical recruitment		$\tilde{\theta}_{amplitude}$

M-A.3. Fishing dynamics

Fishing mortality rate *F* is calculated according to a catchability coefficient, annual effort *E*, age-selectivity *s*, the retention rate (probability of retaining a fish given it is caught) *R,* the discard mortality rate $\tilde{\theta}_{Mdisc}$ (fraction of released fish that die):

16. $F_{y,a,r} = q\ E_y\ s_{y,a}$

The catchability coefficient is calculated by numerical optimization such that stock depletion in the current year matches user-specified depletion $\widetilde{D}$ (spawning biomass relative to unfished levels):

17. $q = opt\big(\widetilde{D} \mid E_y, s_{y,a}, R_a, \tilde{\theta}_{Mdisc}, M, \tilde{h}, W\ \big)$

Meeting the condition:

18. $\frac{S_c}{S_0} = \widetilde{D}$

Vulnerable biomass *V* in each year is the product of numbers *N*, weight *w* and age selectivity *s*:

19. $Vy = \sum_{a=1}^{n_a} N_{y,a}\, W_{y,a}\ s_{y,a}$

The selectivity at age, $s_{y,a}$, was assumed to be age specific, and was initially based on the Cefas stock assessment outputs of selectivity at age. Historical selectivity at age changed in 1998 to reflect the elimination of round haul gear, which selected smaller, younger fish. The selectivity in the forward projections was assumed to be the current selectivity, and no changes were modeled.

In historical simulations, catch in numbers *C*, are calculated using the Baranov equation:

20. $C_{y,a} = N_{y,a}(1 - e^{-Z_{y,a}})\,\frac{E_y\ s_{y,a}\ R_a}{Z_{y,a}}$

In projected years when the fishery is controlled via TACs (limits on the weight of landings) the equations are reversed and fishing mortality rates are calculated from prescribed catches. We assumed that TACs are implemented perfectly in this fishery. Fishing mortality rates are then calculated from the TAC subject to the constraint that they do not exceed user-specified F_{max}.

M-A.4. Observation model

The HCRs tested in this analysis rely on an estimate of the absolute SSB each year. Here we simulate two kinds of error that may affect the reliability of this estimate. The estimate can include consistent biases (e.g. underestimates) in addition to error (e.g. lognormal observation error in annual catches).

Annual observed Spawning Stock Biomass (S) is calculated by multiplying numbers-at-age N by weight-at-age W and maturity-at-age m and adding observation error and bias through a factor term ω:

21. $S_y^{obs} = \omega_{B,y} \sum_a^{n_a} N_{y+1,a+1} m_a W_a$

The biomass factor ω_B includes both bias $\tilde{b}_B$ and imprecision $\tilde{\sigma}_B$ in observations.

22. $\omega_{B,y} = \tilde{b}_B \, exp\left(\varepsilon_{B,y} - \frac{\tilde{\sigma}_B}{2}\right)$

where bias $\tilde{b}_B$ is an improper fraction (e.g. $\tilde{b}_B$ = 1.2 is equivalent to a 20% positive bias) and the lognormal error term ε, is drawn from a standard normal distribution whose standard deviation $\tilde{\sigma}_B$ is sampled at random in each simulation:

23. $\varepsilon_{B,y} \sim N(0, \tilde{\sigma}_B)$

By default DLMtool samples simulation-specific observation error $\tilde{\sigma}_B$ from a uniform distribution.

24. $\tilde{\sigma}_B \sim U(LB_B, UB_B)$

and bias $\tilde{b}_B$ from a log-normal distribution:

25. $\tilde{b}_B = \; exp\left(\varepsilon_{bB} - \frac{\sigma_{bB}}{2}\right)$

26. $\varepsilon_{bB} \sim N(0, \sigma_{bB})$

This convention means that the user can specify an unbiased (e.g. low σ_{bB} and therefore sampled values of $\tilde{b}_B$ close to 1) or a biased (e.g. high σ_{bB} and therefore sampled values of $\tilde{b}_B$ substantially lower or higher than 1) time series that can be observed with a low degree of error (e.g. low sampled values of $\tilde{\sigma}_B$ specified by lower LB_B and UB_B) or high degree of error (e.g. high sampled values of $\tilde{\sigma}_B$ specified by higher LB_B and UB_B).

Appendix M-B: Additional Figures

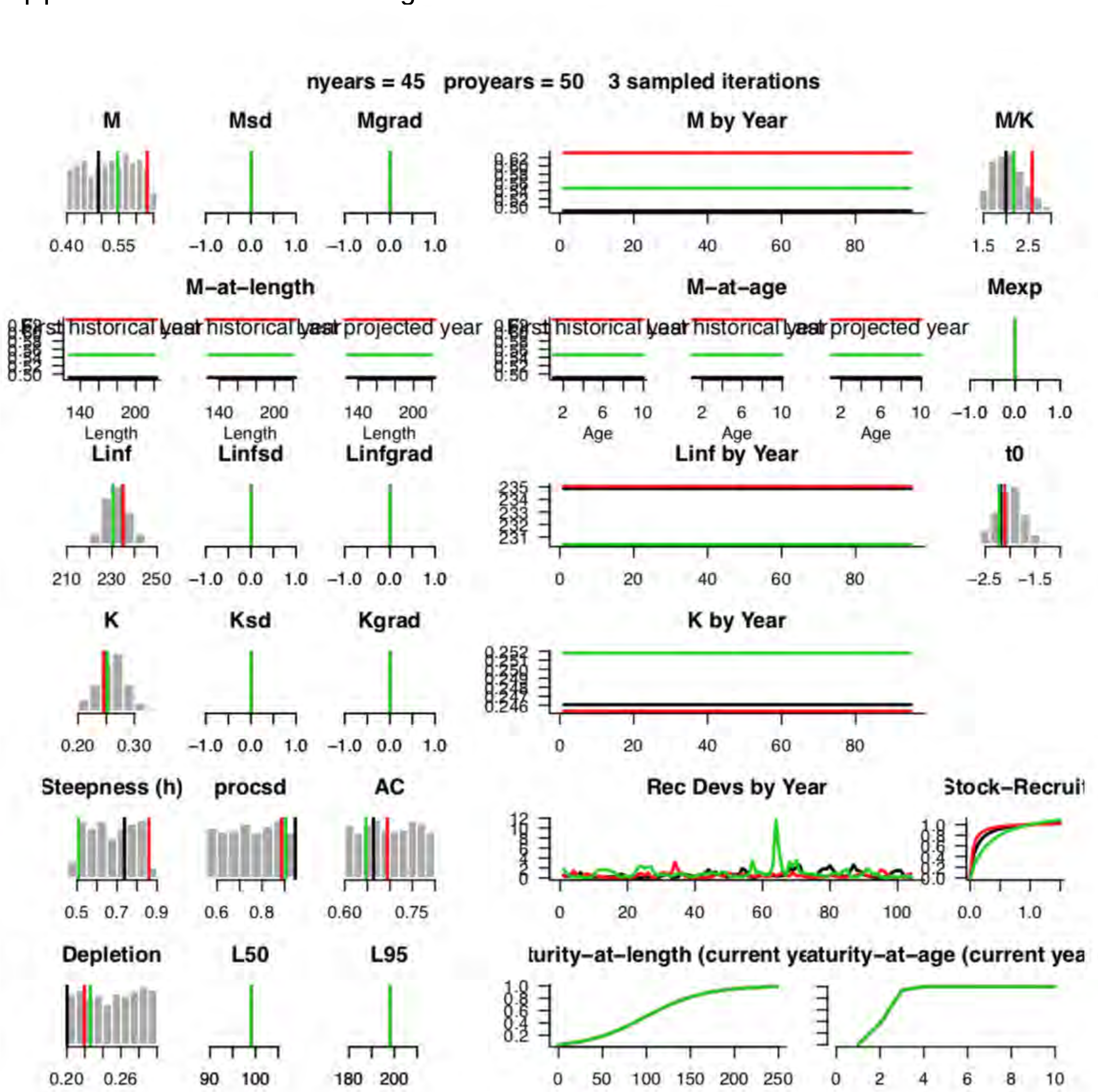


Figure M-B-1. Sampled derived biological parameters for San Francisco Bay Herring under the base model assumptions.

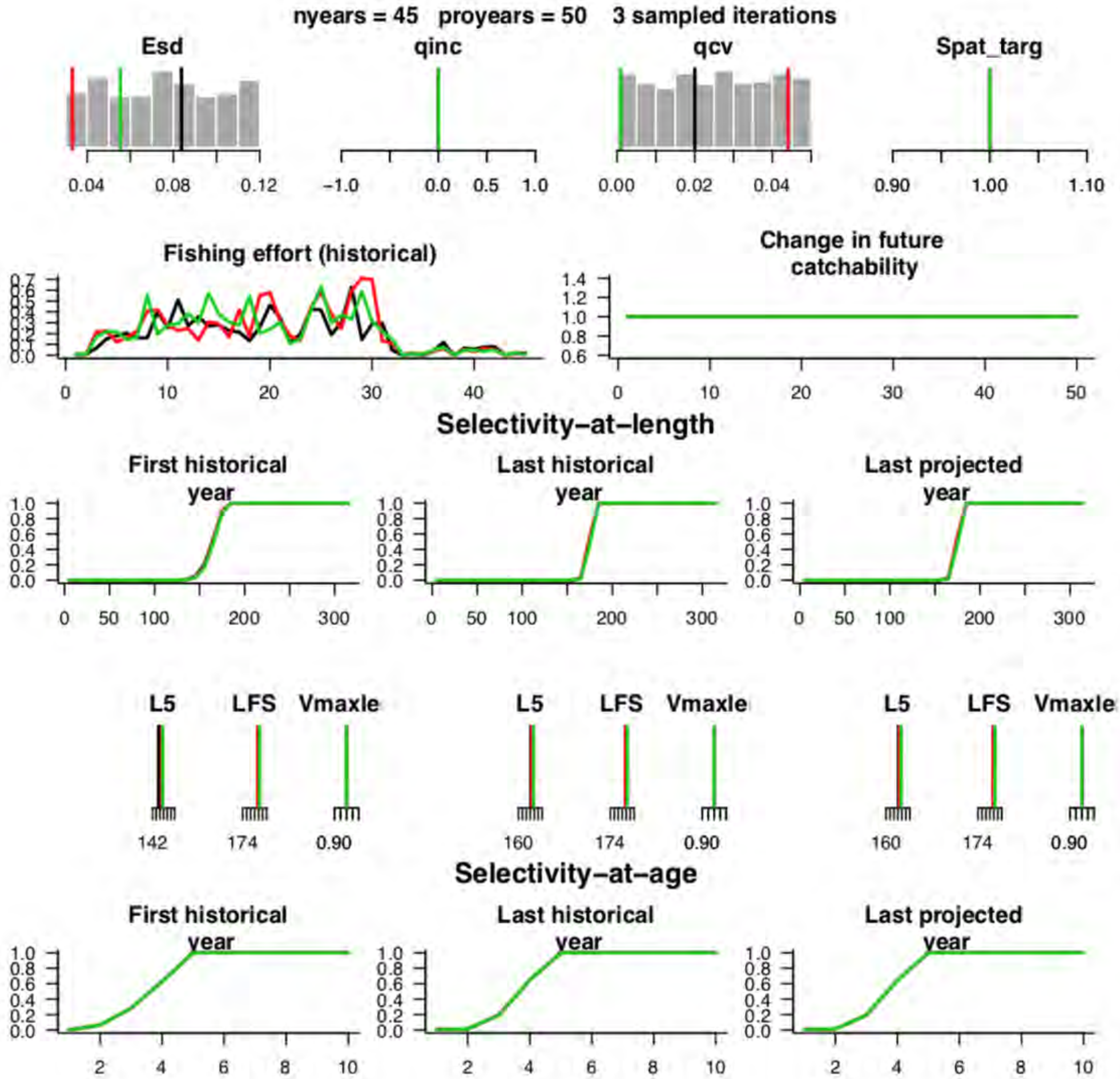


Figure M-B-2. Sampled and derived fleet parameters for San Francisco Bay Herring under the base model assumptions.

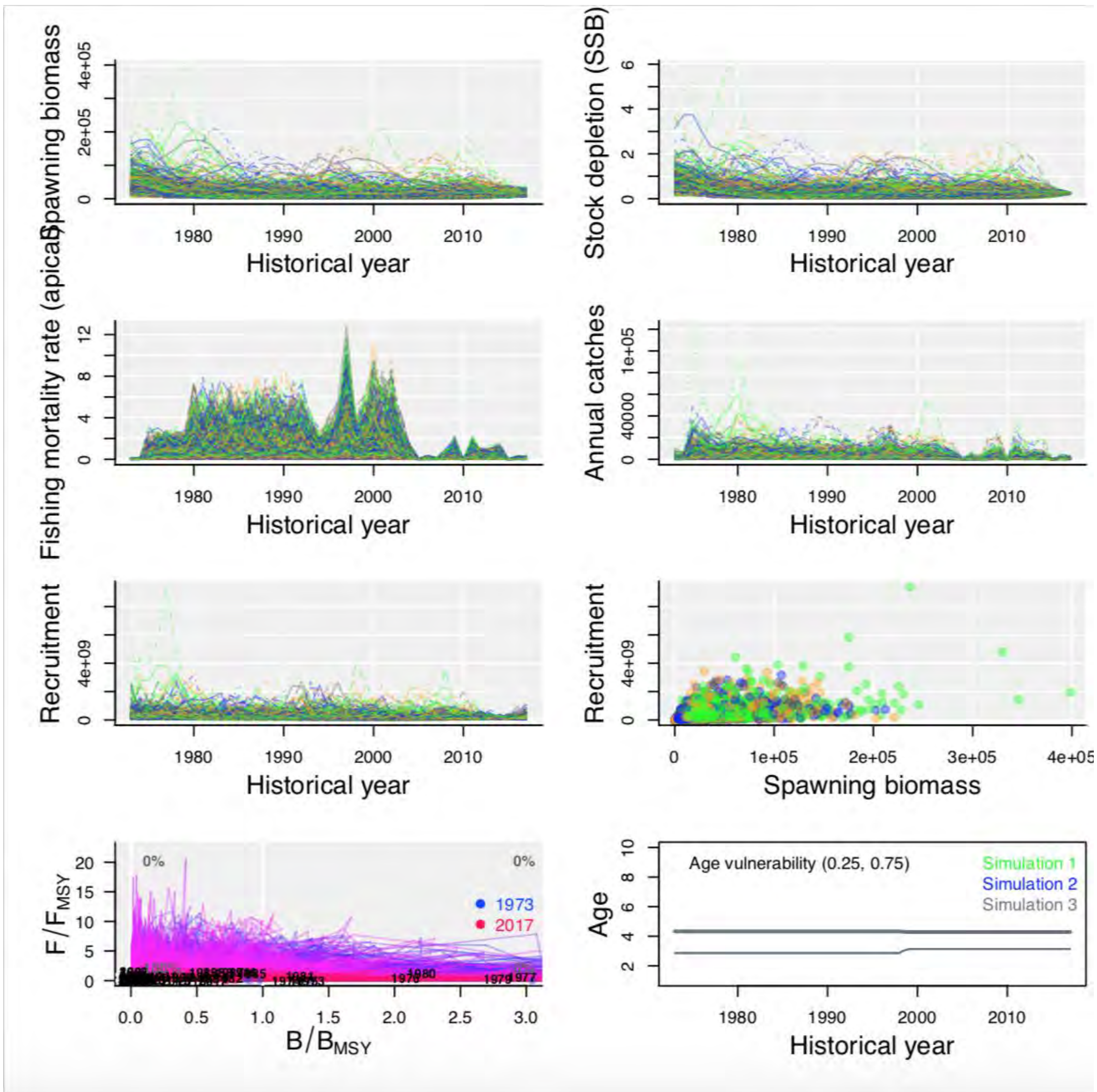


Figure M-B-3. Historical simulations under base model assumptions.

Appendix N Herring Eggs on Kelp Quota Considerations

This Fishery Management Plan (FMP) establishes a new management procedure for setting the Herring Eggs on Kelp (HEOK) sector quota as part of the commercial Pacific Herring (Herring), *Clupea pallasii,* fishery in the San Francisco Bay management area. Previously, the HEOK sector quota was allocated a proportion of the total San Francisco Bay quota. The HEOK quota was expressed as its 'equivalent' whole fish weight, subtracted from the total San Francisco Bay quota and then converted to the total HEOK product weight quota. The HEOK quota was then assigned to individual permits that elected to fish that sector.

During FMP development a wide range of exploitation rates were evaluated while building the Harvest Control Rule. At that time Department of Fish and Wildlife (Department) staff explored the HEOK relationship to the overall quota and examined potential impacts on the spawning stock through egg removals. Appendix A documents the available information on survival rates of Herring eggs to adult fish, both in the literature and from the available data from San Francisco Bay, which suggests that only a tiny fraction of eggs laid survive to return as spawners. Based on this information, along with the information presented in this document describing the small percentage of total eggs removed by the HEOK sector each year, the impact of HEOK removals on the sustainability of the San Francisco Bay Herring population is likely to be negligible. As a result, this FMP establishes a new method to determine HEOK quotas.

One of the changes that will occur as part of the implementation of this FMP is an update to the permitting system. Originally, HEOK participants were gill net permit holders that elected to convert their permits to a HEOK permit each year. As such, HEOK quotas were originally set by transferring a proportion of the total gill net quota to HEOK quotas. However, the fisheries are very different and the FMP presents an opportunity for the Department to restructure the permitting and quota setting processes such that HEOK permits are completely separate from gill net permits. As part of the implementation of this FMP the HEOK quota will be set at a product weight equal to 1% of the total quantity of eggs produced by the estimated Spawning Stock Biomass (SSB), rather than by converting a percentage of the gill net quota. The remainder of this appendix summarizes the historical relationship between estimated SSB and the quantity of eggs spawned by that stock during spawning season, as well as historical quotas and exploitation rates by the HEOK sector.

Stock Size and Quantity of Eggs Spawned

From the 1989-90 season (when the HEOK fishery began) through the 2017-18 (most recent) season, reported SSB in San Francisco Bay has ranged from a minimum of 4,844 short tons (4,394 metric tons) in 2008-09 to a maximum of 145,053 tons (131,590 metric tons) in 2005-06. The average reported SSB during this period is 44,229 tons (40,124 metric tons). The quantity of eggs spawned by a given season's SSB can be calculated based on a San Francisco Bay Herring fecundity estimate of 113 eggs/gram body weight of combined 50:50 male to female fish (Reilly and Moore, 1986; Spratt, 1986). At this estimated fecundity, 1 ton (0.9 metric tons) of 50:50 male to female sex ratio Herring produce 102 million eggs. First, annual escapement must be calculated by subtracting annual sac-roe sector fishery mortality (landings) from reported SSB (fishery mortality occurs prior to spawning, but landed fish are still considered to be part of the total SSB). During the same 1989-90 through 2017-18 period, the quantities of eggs produced annually by the portions of the spawning stock that escape fishery mortality range from a minimum of 0.5 trillion eggs to a maximum of 14.8 trillion eggs. The average annual egg production during this period is equal to 4.2 trillion eggs.

Quotas and Intended Harvest Percentage

The historical quota for HEOK in San Francisco Bay (1989-90 to 2017-18) has ranged from a minimum of 12.3 tons (11.2 metric tons) of HEOK product (excluding the 2009-10 season, during which commercial Herring fishing was closed) to a maximum of 286 tons (259 metric tons), with an average of 69.1 tons (62.7 metric tons) of product. This equates to a minimum of 5.6 billion eggs and a maximum of 130.4 billion eggs, with an average of 31.5 billion individual eggs taken by the San Francisco Bay HEOK sector annually.

Since quotas are set prior to the season during which they are applicable, it is useful to consider annual HEOK quota as a percentage of the eggs spawned during the prior season. This allows for a consideration of historical HEOK quotas in terms of the 'intended harvest percentage' being provided to the sector. The concept of intended harvest percentage is grounded in the idea that, despite substantial observed year-to-year variability in SSB (and thus the number of eggs produced each year), absent a predictive model, the most recent stock estimate is the best indicator of anticipated stock size available to fishery managers. Using the egg production based on observed SSB and HEOK quota egg number equivalencies above, during the 1989-90 to 2017-18 season period, intended harvest percentages for HEOK have ranged from a minimum of 0.10% to a maximum of 1.38%, with an average of 0.76% (Figure N-1). This suggests that the proposed mechanism of setting quotas at 1% of the SBB estimate would be in line with the quotas that have been set historically.

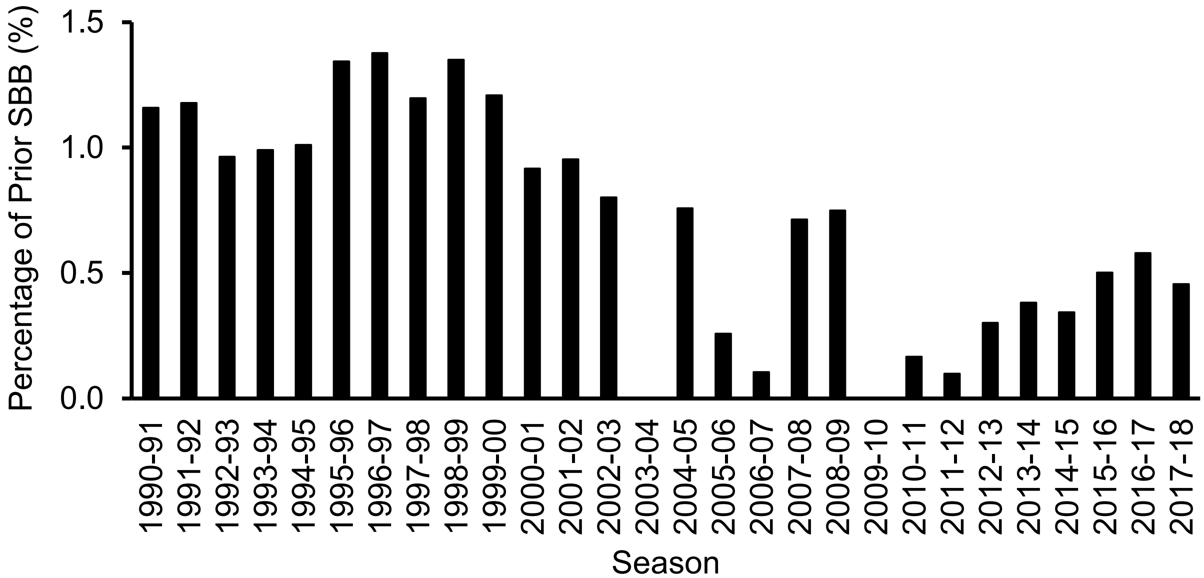


Figure N-1. HEOK quota as a percentage of the previous season SSB estimate from the 1990-91 to 2017-18 season. Note that in the 2003-04 season there was no SSB estimate available, and in the 2009-10 season the fishery was closed.

Landings and Exploitation Rate

Annual landings of HEOK product are reported and historical landing amounts are available in units of short tons of product landed. Considering only years during which landings occurred in this sector of the fishery, these landings range from a minimum of 3.3 tons (3.0 metric tons) to a maximum of 185.7 tons (168.5 metric tons), with an average of 48.3 tons (43.8 metric tons) of product landed annually during years when landings occurred (Figure N-2). Annual landings in tons of HEOK product can also be expressed as number of eggs taken by the HEOK sector of the fishery using the estimated tonnage of Herring required to produce a ton of HEOK product (roughly 4.47 ton (4.06 metric tons) of whole fish) (Spratt, 1992), along with the above fecundity estimate. In numbers of eggs removed, HEOK landings during the 1989-90 to 2017-18 season period have ranged from a minimum of 1.5 billion eggs to a maximum of 85.1 billion eggs, with an average of 22.6 billion eggs (Figure N-1, right axis).

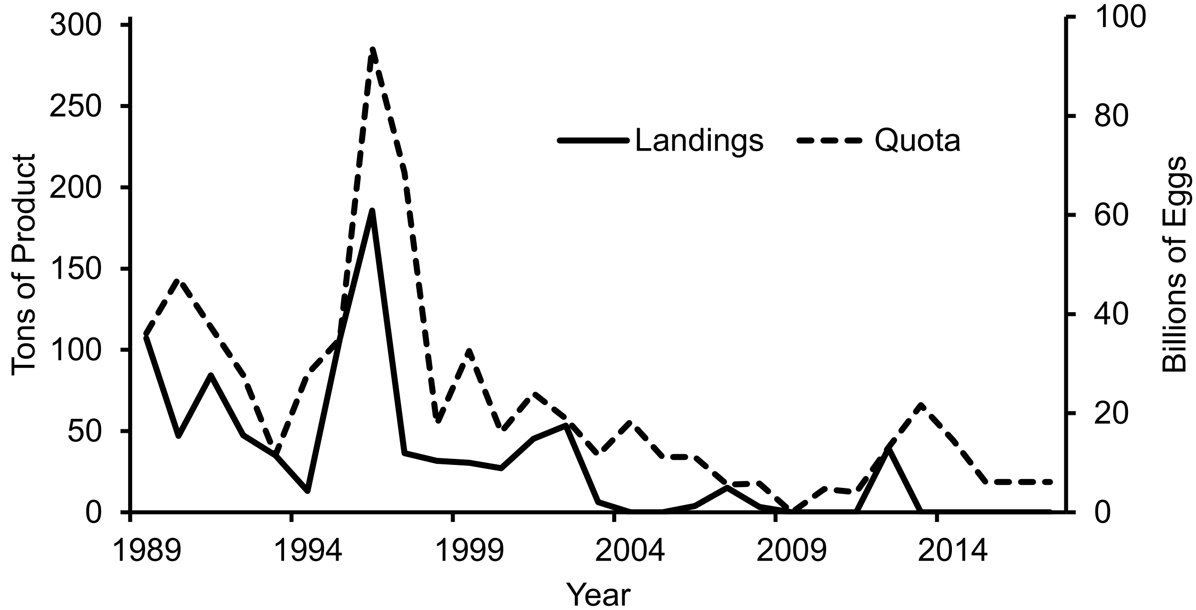


Figure N-2. Historical HEOK landings and quota in tons of product (left axis) and billions of eggs (right axis) between the 1989-90 season and the 2017-18 season. Note there has been no HEOK fishing since the 2012-13 season.

Exploitation rate for the HEOK sector is defined as the amount of product actually landed during a given season relative to the amount of total spawn produced by the SSB during that same season. For years that landings were made by the HEOK sector during the 1989-90 to 2017-18 season period, exploitation rate has ranged from a minimum of 0.16% to a maximum of 1.34%, with an average exploitation rate of 0.56% during that period. This means on average, the HEOK fishery has removed half a percent of the total eggs laid by the Herring stock each season. The fishery has been unable to attain the quota during some of years, in part because it is difficult to induce Herring to spawn on rafts that are tied up in stationary locations. In other years, no fishing occurred due to market reasons.

Appendix O Scientific Review of the Draft Fishery Management Plan for Pacific Herring

Final Report of the Scientific and Technical Review Panel

Scientific review of the draft Fishery Management Plan for Pacific herring (*Clupea pallasii*)

Convened by the California Ocean Science Trust

Supported by the California Ocean Protection Council

October 2018

CALIFORNIA OCEAN SCIENCE TRUST

Review Participants

CALIFORNIA OCEAN SCIENCE TRUST

California Ocean Science Trust is a boundary organization. We work across traditional boundaries, bringing together governments, scientists, and citizens to build trust and understanding in ocean and coastal science. We are an independent non-profit organization established by the California Ocean Resources Stewardship Act (CORSA) of 2000 to support managers and policymakers on the U.S. West Coast with sound science, and empower participation in the decisions that are shaping the future of our oceans. For more information, visit our website at www.oceansciencetrust.org.

Ocean Science Trust served as the independent appointing agency in alignment with the Procedural Guidelines for the California Department of Fish and Wildlife's Ad Hoc Independent Scientific Advisory Committees. Ocean Science Trust convened the review panel and designed and implemented a scientific review process that promoted objectivity, transparency, and scientific rigor (see Appendix A).

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CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

The mission of the Department of Fish and Wildlife is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

California Department of Fish and Wildlife staff were engaged throughout the review process. They delivered presentations to the review panel and supplied additional data, information, and feedback to Ocean Science Trust as necessary throughout the review process.

Ryan Bartling, Environmental Scientist, California Department of Fish and Wildlife, was the primary management contact for this review.

Table of Contents

Recommended citation: Hazen E, Okamoto D, Selden R, and Szuwalski C. Final report of the scientific and technical review panel: Scientific review of the draft Fishery Management Plan for Pacific herring (*Clupea pallasii*). California Ocean Science Trust, Oakland, CA. October, 2018.

Photo credits: CDFW (front cover, p 5, 6, 13, 21, 23); creative commons (p 9, 10, 15); Ryan Meyer (p 18); OST (back cover)

Background

The San Francisco Bay Pacific herring (*Clupea pallasii*) population supports a valuable fishery for herring roe (kazunoko), and a smaller herring-eggs-on-kelp (komochi or kazunoko kombu) fishery. San Francisco Bay also supports a limited commercial fresh fish and recreational fishery. The California Department of Fish and Wildlife (CDFW) developed a draft fishery management plan (FMP) to guide commercial and recreational fisheries for Pacific herring to ensure sustainable fishing levels.

FMPs assemble information, analyses, and management options to guide the management of the fishery by CDFW and the Fish and Game Commission (Commission). The FMP becomes effective upon adoption by the Commission, following their public process for review and revision. Thus, it is important for the scientific underpinnings of the draft FMP to have undergone independent review prior to submission to the Commission. External, independent peer review of the scientific underpinnings of the draft FMP is one way to provide the Commission and stakeholders assurances that FMPs are based upon the best readily available scientific information, as set forth under the Marine Life Management Act (MLMA).

REVIEW SCOPE

Ocean Science Trust worked with CDFW to develop a scope of review focusing on the scientific and technical elements of the proposed management framework that will guide fishery management decisions for the San Francisco Bay Pacific herring stock in the Pacific herring draft FMP and supporting materials. Thus, the review is not intended to be a comprehensive assessment of the entire draft FMP or the proposed approach to management contained therein, but rather focuses on key components identified below. This review focussed on whether the available data and predictive model that underpin the proposed draft FMP management strategy are applied in a manner that is scientifically sound, reasonable, and appropriate. Therefore, the central question of this review was:

Given CDFW's available data streams and analysis techniques, are the applications of the analyses to the integrated management strategy scientifically sound, reasonable, and appropriate?

Specifically, the review focused on evaluation of the following components of the draft FMP:

1. The accuracy and representation of existing literature on the biology of the stock and in the essential fishery information
2. The proposed spawning stock biomass thresholds and associated harvest rates underpinning the catch quota decision making process and signaling when the fishery may warrant management response
3. The decision matrix of ecosystem indicators and the rationale behind the inclusion of these ecosystem indicators in management
4. The science underpinning additional conservation and management measures
5. Identification of research and methods needed to improve assessments and fishery management in the future

For clarity we note that the following are not included in the scope of the current review:

- The data collection protocol, as it has been reviewed previously.
- The new predictive SSB model for spawning stock biomass, as the model underwent separate peer review and was published (Sydeman et al., 2018).

SUMMARY OF THE REVIEW PROCESS

This review took place from February 2018 - October 2018. Ocean Science Trust implemented a scientific review process that sought to promote objectivity, transparency, candor, efficiency, and scientific rigor. Following a broad solicitation for potential reviewers, coordinated via the Ocean Protection Council Science Advisory Team, a multidisciplinary, four-member review panel was assembled, representing expertise in fisheries science and management, marine ecology, stock assessment, and modeling. Ocean Science Trust facilitated constructive interactions between reviewers and CDFW through a series of remote meetings, where CDFW staff provided reviewers with the management context, presented an overview of the science and technical elements under review, and were available to answer reviewers' questions. In addition, Ocean Science Trust convened reviewers independently to allow the review panel to candidly discuss the review materials and conduct their assessment. Ocean Science Trust worked with the review panel to assemble and synthesize their written and verbal responses to guiding questions, as well as discussion from remote meetings into this final report. This report is publicly available on the Ocean Science Trust website.

PROJECT MATERIALS UNDER REVIEW

The following materials were provided by CDFW to the review panel for scientific and technical review:

- Draft Pacific herring Fishery Management Plan, Chapters 2-8.
- Draft Pacific herring Fishery Management Plan Appendices, 200 pages.

Additional data and information were provided by CDFW at the request of the review panel to assist with their assessment throughout the review process.

Review and Recommendations

Foremost, the review panel acknowledges the impressive effort that went into developing the management strategy in the Pacific herring draft fishery management plan (FMP) by the California Department of Fish and Wildlife (CDFW), the Pacific herring Steering Committee, other stakeholders, and outside experts, including the Farallon Institute. The preparers of these documents have thoughtfully considered a diverse amount of information. CDFW produced a management approach for the San Francisco Bay Pacific herring stock that integrates economic, ecological, and population considerations in a simple, flexible, and precautionary framework. The commitment to sustainability is clear, with a focus on minimizing years of a depressed stock, maintenance of a healthy age structure, maintenance of an economically viable fishery, and ensuring Pacific herring remain an important component of the ecosystem. The review panel believes these goals are both appropriate and commendable.

There are, however, details and further considerations that may improve the overall draft FMP and future performance against objectives. Additional scientific guidance and considerations are included that would produce a more scientifically robust FMP, as well as longer-term recommendations, data, and research needs that would strengthen the science contained within the draft FMP and its ability to inform management as new information and analyses become available. These recommendations will be addressed in more detail in the following sections.

This assessment is structured around the key focal areas identified in the scope of review (page 4). These recommendations aim to improve the science supporting the proposed management framework and, where possible, provide insight on the implications of each recommendation.

In addition to the recommendations included in this assessment, reviewers also provided in-text comments to CDFW. These comments did not substantially change the content of the draft FMP, but supported the improvement of the FMP document. Any comment that required additional discussion was pulled out and included in this report. In-texts comments included:

- The addition of citations
- Suggested edits to language for clarity and comprehension

Below are the scientific review panel's recommendations. Recommendations are identified as those that CDFW should address prior to adopting the FMP, and those that are longer-term considerations, which could be addressed following adoption of the FMP.

1. ESSENTIAL FISHERY INFORMATION

In accordance with the Marine Life Management Act (MLMA) sustainability objectives, CDFW is required to collect and maintain the most up-to-date Essential Fishery Information (EFI). The EFI includes information about species biology and life history, habitat requirements, population dynamics, fishing effort, catch level, socio-economic value of the fishery, and other information that would permit the fishery to be managed sustainably. The draft FMP also outlines how to address missing or outdated EFI.

Overall, reviewers found the representation of the existing literature on the biology of the stock was accurate and considered much of the core and relevant information. However, the panel did have recommendations for where clarification would be helpful and additional information gaps could be filled. Section 1.1 contains key recommendations that would allow for greater clarity and a more robust approach and should be considered before adopting the FMP. Section 1.2 includes recommendations that could improve the management of the fishery but are not imminent priorities and/or may require longer-term investment and research.

1.1 Key recommendations

1.1.1 Fecundity

Mass-specific fecundity is a core component of calculating spawning biomass from egg deposition surveys. The current estimates of fecundity and the relationship with weight, as stated within the draft FMP, require further justification. Specifically, it is well known that fecundity per unit mass varies with mass and length, as well as environmental conditions in herring. As a result, applying a single mass specific conversion requires justification. For example, this may be as simple as providing evidence that mass-specific fecundity is reasonably close to consistent regardless of female body mass, and is relatively time-invariant. Moreover, the rationale for monitoring fecundity infrequently, and how that information is used to update estimates, requires discussion. Specifically, Chapter 3 notes that,

> *"Direct fecundity measurements are resource intensive, and so the Department only measures fecundity periodically (approximately once a decade; R. Bartling, Personal Communication). Currently, the Department assumes a fecundity rate of 217eggs/g for females in San Francisco Bay, though a recent estimate suggests that fecundity may have declined during the warm water conditions between 2013 and 2016 (Table 3-5). The fecundity, along with the sex ratio of each observed spawning wave, is used to calculate the total weight of fish that must have laid the number of eggs observed in spawn surveys."*

Collecting higher-resolution information on fecundity should be an important part of EFI and lack of this information should be discussed and justified beyond the fact that they are resource intensive. Moreover, what "approximately once a decade" means should also be described in either in text or in a table with actual information about sampling years, estimates, and plans for continuation of collection of these data. These recommendations are included as a priority, in part, because using outdated or poor estimates of fecundity can impose substantial bias on estimates of spawning biomass.

1.1.2 Spatial and temporal variation

More clarity on the spatial structure of the Pacific herring populations, including maps, graphics and detail to describe how and why populations vary over time is needed.

Additionally, it was not immediately clear in the current draft how spatial information included fit together to inform the management strategy. Questions around whether spatial samples of age structure and sex-ratio are weighted by biomass need to be addressed. If not, skewed sex ratios or age structure from small spot spawns may disproportionately affect overall estimates if they have similar sample sizes for these metrics. It would also be useful to consider if spatial distributions of biomass could be used to inform when and where fisheries occur.

Similar to spatial information, it is currently unclear how temporal information is aggregated to inform the management strategy. Specifically, spawning waves often vary in sex ratios, size-at-age, and age structure. The draft FMP should describe how this information is brought together and whether, during sampling, there is a concerted effort to capture this variation.

1.1.3 Rapid Spawn Assessment Method

The reviewers recognize the potential value of an efficient alternative to the current survey protocols for use in areas outside of San Francisco Bay. However, the current description of the Rapid Spawn Assessment Method lacks sufficient detail. Reviewers would like to see specifics about methods of data collection, data produced, their utility, and a summary of results/products thus far included in the draft FMP. To assess the validity of the method, CDFW should also provide any information on, or plans for, assessment of this approach when applied to data-rich San Francisco Bay. Specifically, are quantitative or qualitative trends comparable between the full spawning protocols and the Rapid Spawning Assessment Method in San Francisco Bay? It would also be useful to provide information on potential costs as compared to current data collection protocols. In sum, if this approach is to be included in the FMP, please provide sufficient detail to evaluate its efficacy and purpose; otherwise, it should be removed.

1.1.4 Monitoring of young-of-year (YOY)

The proposed statistical model used for forecasting spawning stock biomass relies on indices of abundance of YOY. These data are thus a core priority for managing this fishery. The FMP should therefore adequately address the importance of conducting these surveys annually and with sufficient investment to ensure data quality that matches or exceeds recent records used to calibrate the statistical models.

1.2 Longer-term recommendations

While CDFW has an abundance of EFI for the San Francisco Bay Pacific herring stock, they should consider additional data sources and/or research and monitoring in support of acquiring and maintaining the most up-to-date EFI to support a sustainable Pacific herring stock. These data may include higher resolution monitoring of female fecundity, spatial and temporal genetic structure, spatial variation in growth rates, habitat availability and suitability, maturity-at-age, and any information on range shifts within and around the San Francisco Bay. These data would be helpful to test whether assumptions made about the stock dynamics are accurate and to improve forecasts of stock biomass.

Specific longer-term considerations for essential fishery information are listed below:

1.2.1 Population structure

There is a new body of evidence from northern populations of Pacific herring that spawning aggregations separated by several weeks or more in timing exhibit genetic differentiation when using high resolution molecular markers (L. Hauser and E. Petrou, unpublished data). Given that spawn timing in San Francisco Bay spans months, CDFW may consider utilizing these new markers to evaluate if there is genetic structure by spawn timing or geography. These may help inform whether spatial or temporal considerations in management are necessary.

In addition, given this is the southern end of their range, there is a high potential for range shifts in the future. Longer-term objectives assessing trends, poleward shifts, and climate relationships with spawning distribution would provide valuable insight into the future persistence of herring spawn in California (also discussed in Section 5.1). Such data may require detailed spatial records of spawn observations along the California coast. These data may include formal or ad-hoc data collection from spawn flights, anecdotal records, or other sources.

1.2.2 Maturity-at-age and fecundity

CDFW should consider studies that attempt to estimate maturity-at-age and whether that changes over time. Given that fish growth rates have changed dramatically over time (DFO 2015), there is no reason to assume that historical estimates of maturity-at-age reflect their current values. These data will be useful in any attempt to construct a stock-assessment and in translating information about YOY surveys to future spawning biomass forecasts.

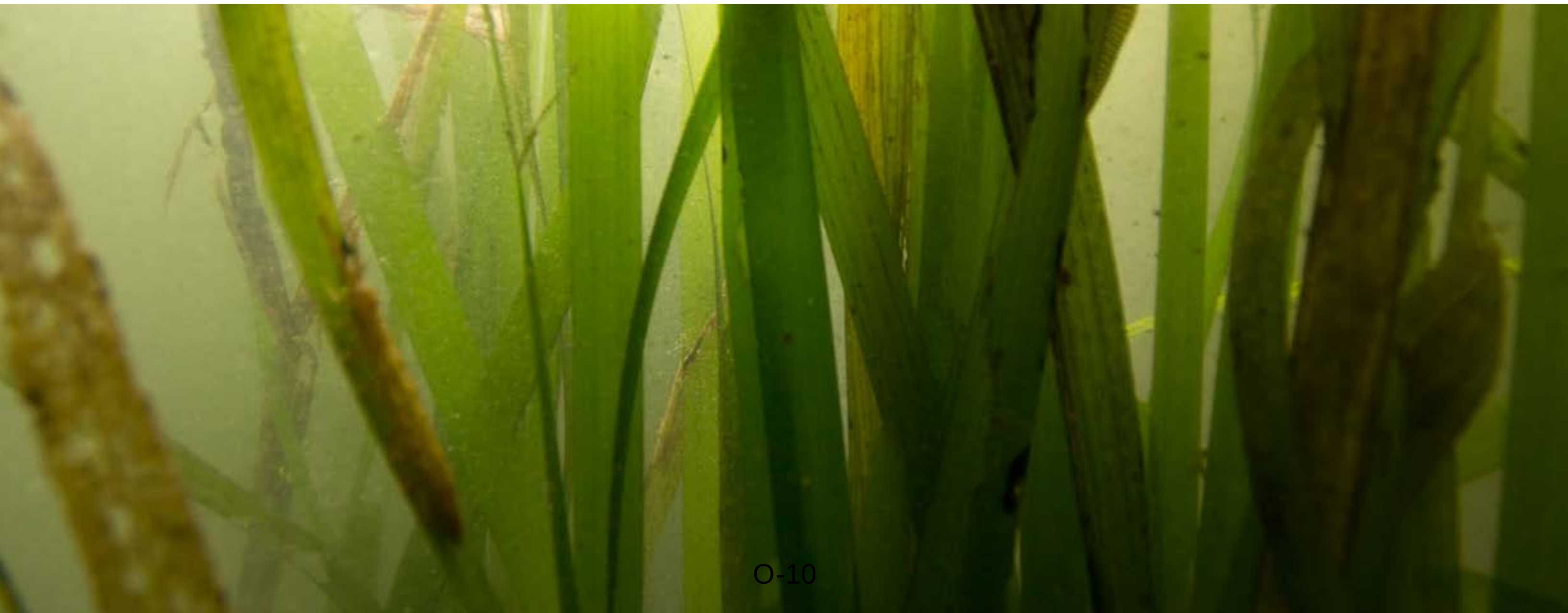
Likewise, the reviewers recommend conducting higher frequency of female fecundity monitoring as size/age structure is changing. If data currently being collecting about fecundity are insufficient, CDFW should consider undertaking studies that attempt to estimate current maturity-at-age.

1.2.3 Spawning habitat availability

Herring in the San Francisco Bay utilize eelgrass (*Zostera* spp) and red algae (*Gracillaria* spp) in addition to other physical and biological spawning habitat. Surveys are conducted to assess habitat availability in terms of kilogram per square meter. However, how and if this information is utilized to assess total availability of habitat, what current trends are, and how it compares to other habitat surveys (of eelgrass beds, for example) remains undescribed. The reviewers recommend at least providing some context and background addressing these questions given that these data are on hand.

2. EVALUATION OF SPAWNING STOCK BIOMASS THRESHOLDS AND HARVEST RATES

The draft FMP's aim is to provide an adaptive management strategy for the California Pacific herring fishery that achieves 'sustainability' by implementing a harvest rate of no more than 10% of spawning stock biomass (SSB) each year. However, it is not currently possible to estimate in-season SSB due to management resource constraints. Therefore, quotas for next season are set based on a percentage of the previous season's SSB. This method assumes a relatively stable herring stock size from year to year, but herring SSB has exhibited higher interannual variability since the early 1990s. Consequently, the use of last year's SSB as a proxy for the coming year has become less useful over time. Recently, correlations between indicators of herring stock health and environmental indices have been used to develop a predictive model to estimate the coming year's SSB. This proposed predictive SSB model has been published in a peer-reviewed journal (Sydeman et al., 2018) and at least partially addresses the problem of using last year's SSB as a proxy for this year's SSB by incorporating a



recruitment index and environmental indices. As proposed in the draft FMP, the harvest control rule (HCR) framework is based on this predictive model and the presented management strategy evaluation (MSE) for the San Francisco Bay herring stock. This review did not assess the HCR based on the empirically-based SSB, which would require additional review.

Overall, the review panel is fairly confident that the proposed predictive SSB model as applied in the proposed HCR is appropriate to meet the ecological management objectives of the fishery, given relatively conservative targets for exploitation rates which should be robust to sampling error and population variability (provided the potential problems with fecundity and weight described above are addressed). However, it was more difficult to determine if this HCR as proposed would meet 'economic viability' objectives because no quantitative information was provided on how economic viability was determined, nor were economic objectives directly incorporated into the MSE (catch and variability were included, but these are indirect measures of economic viability).

Below are the review panel's specific evaluations of: the application of the proposed predictive SSB model (Section 2.1), the interpretation and application of MSE results (Section 2.2), and considerations for future investment (Section 2.3). Sections 2.1.1 and 2.2.1 contain recommendations relevant to the proposed predictive SSB model and MSE, respectively, that should especially be considered before adopting the FMP. Sections 2.1.2 and 2.2.2 contain recommendations that could improve management of the fishery but are not imminent priorities and/or may require longer-term investment and research.

2.1 Application of predictive spawning stock biomass (SSB) model

Generally, reviewers view switching from the current empirical method to the proposed predictive SSB model (Sydeman et al., 2018) as appropriate for a number of reasons: 1) the model predicts SSB better than the current methods, 2) recruitment, or YOY, surveys provide valuable information on year-class strength that biomass information does not, 3) assuming the current year will be like the previous year is a poor predictive strategy when temporal auto-correlation is low (recently auto-correlation in SSB has decreased), and 4) more accurate predictions resulting from the proposed predictive SSB model reduce the likelihood of over- or under-exploiting the stock. Although these benefits make the proposed predictive SSB model a clear winner over the empirical method, there were several issues raised and the review panel has concerns that the proposed predictive SSB model may not be the best model to use for the longer-term.

2.1.1 Key Recommendations

Demonstrate the expected efficacy of the predictive SSB model in management

The proposed predictive SSB model was not used in the MSE, consequently it is not clear what the projected performance of this model will be. There would be stronger justification for using this model if it had been used in the MSE (discussed more in Section 2.1.2).

Clarify the reasoning for abandoning the stock assessment model in favor of the predictive SSB model

Reviewers understand that the last assessment was not approved, due in part to difficulty in estimating a stock-recruit curve. However, difficulty in estimating a stock-recruit curve should not be a barrier to building an assessment model and is quite common. For example, herring data in British Columbia has a similar structure (DFO 2015) and has effectively estimated a Bayesian age structured assessment model, as have others (Hulson 2007). Information on the age- and size-structure of the population is lost in the proposed predictive SSB model, but an assessment could present this information in a useful format. Consequently, further discussion about the stock assessment's short-comings and its comparison to the proposed predictive SSB model would be useful to ensure the best model is used in management (explored further in Section 2.2).

Explicitly consider and report uncertainty in management outcomes

Uncertainty enters the management process in many places--e.g. observation error in the survey data, process error in environmental forcing, and implementation error in management. Many of these sources of uncertainty were incorporated into the MSE, yet others were not (like the error surrounding the output and input of the proposed predictive model--arguably one of the most influential sources of error in this management strategy). The reviewers emphasize the need to account for and communicate this uncertainty, and mention other places uncertainty could be important in other recommendations below.

2.1.2 Other Recommendations

While the reviewers believe the proposed predictive SSB model will be an improvement in California Pacific herring management, the panel note potential improvements to the proposed predictive SSB model that should be considered in the model's application to management:

Further explore the phase-space between the variables used in the predictive model

The phase-space between the variables used in the proposed predictive SSB model has not been fully explored (i.e. there are values for environmental variables or the recruitment index that have not been observed, and therefore do not have a corresponding observation of spawning biomass with which to make predictions). Consequently, predictions within unexplored regions of the phase-space cannot be made with any certainty. A sensitivity analysis using simulated data fed to the proposed predictive SSB model (and into the harvest control rule in a full-feedback MSE as noted again in Section 2.2.2) would be useful to further evaluate the performance of the model. An example of a potentially problematic scenario is one in which the YOY survey reports zero recruitment, but environmental conditions are ideal which could lead to SSB estimates that are highly uncertain and uncredible. Exploring and accounting for this uncertainty will be critical to effective management.

Carefully consider assumptions of the model

Assumptions of the model (e.g. additive effects of temperature; assumed Gaussian errors rather than log-normal; errors in variables; jack-knifing vs. k-fold cross-validation) would also be useful to carefully scrutinize and provide justification. Justifying the assumptions of the model would bolster confidence in the output of the proposed predictive SSB model and its use in management.

Directly address and consider uncertainty inherent in predictive SSB modeling and data inputs

Using linear temperature forecasts has the potential to produce conditionally biased results. The existence of such bias can be partially examined using existing data by examining trends in out-of-sample error in the forecast associated with temperature. Consideration of model averaging for the forecasts may be useful in the proposed predictive SSB model. The difference in Akaike Information Criterion (AIC) between the model with-versus-without sea surface temperature (SST) is small (3 AIC units) suggesting model uncertainty is high and the utility of environmental covariates is low. Additionally, the proposed predictive SSB model does not consider the uncertainty in the estimates of SSB and YOY fed to the model. State-space models would offer the ability to do this.

2.2 Management strategy evaluation to inform the harvest control rule

The outcomes of management strategy evaluations depend upon the input parameters. While many of the input parameters for the presented MSE are not well known, the outcomes of the chosen harvest control rule (HCR) configurations were somewhat predictable and the relationship between their outcomes (e.g. rankings of total yields and closures) would likely be preserved for a range of input parameters. In general, while the review panel would not necessarily recommend choosing a different HCR, some concern was expressed related to the scientific backing for the input parameters, performance metrics, model structure, and a relatively high closure rate for the chosen HCR (discussed below).

2.2.1 Key Recommendations

Incorporate the predictive SSB model into the MSE

One of the key purposes of an MSE is to test the performance of "estimation models" (here the predictive SSB model) to be used in management. Per Appendix 11 describing the MSE, this was not done here. Therefore, the reviewers cannot effectively assess how the proposed predictive SSB model performs relative to the empirical model (or other potential assessment methods). In order to strengthen the justification for switching from the current empirical method to the proposed predictive SSB model, the MSE should be run using the proposed SSB model.

Explain the process for selecting final candidate HCRs for the MSE

The review panel understands that the stakeholder engagement process was key in determining the biomass cut-offs and final five candidate HCRs. It would be helpful to include in the draft FMP a description of the full range of cut-offs and HCRs considered and how those were bounded based on stakeholder discussions. The five HCRs run through the MSE seem reasonable given the materials available to reviewers during the review, but it would be useful to know what pitfalls were identified previously and why certain HCRs were eliminated.

2.2.2 Other Recommendations

While the reviewers have a range of additional observations and suggestions related to the MSE, they do not believe these should necessarily impact the overall results or the implementation of the FMP.

Consider different/additional input parameters

Parameters determining the productivity of the stock drive the results of these analyses, but they are not well known. The conditioning of the operating model should be considered more closely--based on the information provided to reviewers, the simulated fishing mortality rates over the historical period exceeded 8.0 (Appendix 11 Figure B3), which is questionable given other information on the fishery. Risks to the fishery other than fishing (e.g. risk of oil spills) should also be considered. Additionally, a sensitivity analysis for out-of-bounds predictions would be useful to understand the performance of the HCR to unexplored portions of the phase-space.

Consider different/additional performance metrics

The key objectives of the draft FMP appear to be economic viability of the fishery and minimizing ecosystem impacts, yet the performance metrics did not reflect these two goals well. For highly variable stocks, like Pacific herring, the metrics currently used in the MSE (B_{MSY} and B_0) are poorly defined and consequently do not provide very useful information for management. The key metric for economic viability presented in the completed MSE was closure rates, yet it would be useful to consider others to understand and communicate the different impacts of management. For example, projecting vessel profits based on projected prices and costs of fishing under different management strategies could provide tangible impacts of alternate strategies.

Additionally, there is no metric for ecosystem impact currently included in the presented MSE. There are many ways of approaching this metric, but a potential method would be estimating the size of predator populations that could be supported by the stock after fishing and use the mean/median predator population and its variance as an indicator. In general, the reviewers would have liked to have seen parameters that influence the outcome of the MSE determined by data, and performance metrics that more closely aligned with the goals of the fishery.

Revisit closure rates and the potential impacts on herring population and the fishery

Based on the MSE, the proposed HCR results in a closure rate of 20%. As the precautionary harvest rate already accounts for stock sustainability and variability due to environmental conditions, reviewers were surprised to see a closure rate this high. An in-depth discussion of what specifically is driving the closure rates (given an apparently conservative HCR), if these conditions appear to mirror reality, and how this impacts the economic viability of the fleet would be useful to build robustness and confidence in the HCR. The reviewers are somewhat concerned with what might happen if there was a closure of the fishery two years in a row (which has a relatively high probability of happening in the not-too-distant future with this closure rate), and if this closure rate actually helps to achieve the stated goals of sustainability and stock rebuilding beyond the precautionary harvest rate. The reviewers acknowledge that the decision about what closure rate is "acceptable" is a management decision, but if moving ahead with the proposed HCR, the draft FMP should more explicitly address the implications and uncertainty contained within this predicted closure rate.

2.3 Longer-term recommendations

Revisit exploring a stock assessment

An impressive amount of biological information exists for the San Francisco Bay herring stock. The development and maintenance of a stock assessment model would benefit CDFW by synthesizing and integrating that information into a format useful in management. A stock assessment would allow a framework for managers to ask more complicated questions about changes in management. For example, changes in selectivity could be useful management levers (e.g. changing mesh sizes), but with the proposed predictive SSB model, it is not clear how changes in selectivity might impact management advice or the sustainability of the fishery.

Stock assessment development is an iterative process, so previous rejections of proposed stock assessments should not discourage future efforts. It may be worth first doing a cost benefit analysis for developing the assessment to the point that it is useful in management. Although it is not immediately clear how much more precise and accurate estimates of SSB from a stock assessment would be compared to the proposed predictive SSB model given the life history and available data streams, the review panel agrees revisiting a stock assessment would be a worthy future investment. An explicit side by side comparison between the developed stock assessment model and proposed predictive SSB model in a management strategy evaluation would be useful to understand the costs and benefits of each model.

Iterate the predictive SSB model and perform regular model validation

If the proposed predictive SSB model will be the tool used for the foreseeable future in management, a routine process to evaluate the performance of the model should be developed. The model should be updated yearly with new data, and model accuracy should be reassessed.

3. EVALUATION OF ECOSYSTEM INDICATORS

Pacific herring play an essential part of the California Current Ecosystem as a forage species. As preliminary quotas in the proposed HCR are developed using a single species model to understand impacts to San Francisco Bay populations of Pacific herring (described and reviewed above), they do not explicitly take into account the current status of alternative forage and predator indicators. In recognition of this, a novel approach to incorporating ecosystem indicators was developed as part of the draft FMP. Indicators include: 1) herring productivity, 2) alternative forage availability, and 3) predator populations. The goal of the indicators described in the decision matrix (Table 7-2) is to signal poor conditions when additional precaution in management may be warranted, or healthy conditions when quota may be increased. As proposed, this matrix would provide qualitative guidance to CDFW to determine if adjustments to the preliminary quota are necessary (Figure 7-2). The decision matrix was developed to be adaptive and updated by CDFW as needed to reflect the best available science. Reviewers focused on rationale behind the interpretation and inclusion of these ecosystem indicators in setting final quotas.

Section 3.1 contains the reviewers overall assessment of the ecosystem indicators decision matrix and key recommendation. Sections 3.2 includes recommendations the review panel feel are critical to improving the robustness of the proposed approach, but may require longer-term work.

3.1 Overall assessment

Develop quantitative thresholds, calculate historical scenarios, and provide additional evidence linking ecosystem indicators to specific ecological responses to support using ecosystem indicators to adjust quota

Ecosystem based management approaches are widely recognized as an important next step in both State and Federal fisheries management approaches. Federally, ecosystem indicators are largely used as information in ecosystem status reports broadly (e.g. Harvey et al., 2017), or to inform fisheries ecosystem plans for a specific stock (e.g. Levin et al., 2018). In these scenarios, the environmental information is not currently used in a decision support tool to adjust quotas, but provide the general context on what to expect in the given year and in upcoming years. In addition, these narratives often can provide context for past years where stock size estimates may have been higher or lower than expected.

The ecosystem indicators section of the draft FMP is quite useful in understanding the broader ecosystem context and the review panel is encouraged that efforts are underway to include this information. Incorporating ecosystem indicators is challenging and few successful implementations of ecosystem based methods exist to guide CDFW in their efforts. Given the novel ecosystem approach developed for the San Francisco Bay herring stock, the draft FMP has the potential to lead the way for future ecosystem-informed FMPs. While admirable and ambitious, the reviewers have reservations regarding the proposed framework as it stands, for incorporating ecosystem indicators into the HCR. The proposed rules are vague and not empirically derived from quantitative analysis or tested with MSE, and appear to lack a transparent process for proposition and adoption of deviations from the HCR from year to year. As a result, the reviewers recommend working to build a more transparent, quantitatively based, and tested ecosystem approach.

Reviewers recommend developing quantitative thresholds, calculating historical scenarios to ensure that the thresholds are adjusting the quota as envisioned by CDFW and stakeholders involved, and providing additional evidence linking ecosystem indicators to specific ecological responses. Generally, ecosystem indicators are useful to pursue, but it is equally important to ensure that effort be spent solidifying the single-species research. As single-species methodologies are the building blocks for ecosystem based approaches, focusing on the single-species details (especially economics) can also answer some of the key questions lingering about the impacts of the ecosystem decision matrix. If CDFW decides to incorporate ecosystem indicators in the interim, the FMP should outline the transparent process by which ecosystems-based deviations from the HCR are considered and justified.

Overall, given that the harvest rate cap implicitly considers some ecosystem conditions, the HCR preliminary quota setting serves as a valid approach. Developing thresholds for incorporating ecosystem indicators and a formal process for adopting them would support their inclusion directly in the HCR. Until then, ecosystem indicators could be used, as in Federal fisheries examples, as general context when setting quotas on what to expect in the given year and in upcoming years (more detail below).

3.2 Recommendations to incoporate ecosystem indicators moving forward

This section includes recommendations that are important for building a more robust approach. Addressing these recommendations would improve the application of the ecosystem indicators and the management of the fishery, and may require longer-term investment and research.

Evaluate performance of HCRs corresponding to the bounds of green, yellow, and red conditions (Figure 7-2) within MSE framework

As a first step, the review panel recommends making it more transparent how ecosystem indicators would link to "green," "yellow," or "red" conditions (Figure 7-2). It would be informative to evaluate performance for HCRs roughly corresponding to these limits to understand how ecosystem conditions and a given increase or decrease in quota to these levels would relate to the current performance metrics. Even without explicit linkages between specific ecosystem indicators and potential quota adjustments, the reviewers recommend that these adjusted quotas be formally run through the MSE.

Consider developing ecosystem status reports to support the FMP

The existing HCR and proposed ecosystem indicators could be used down the line to directly inform ecosystem-level advice. In the meantime, ecosystem status reports, also called fisheries ecosystem summaries, can provide a snapshot and synthesis of the state of fisheries, communities, and the broader ecosystem. These summaries can provide ecosystem considerations to support individual fisheries management plans, and serve as the backbone of broader ecosystem-wide assessments. The summaries can describe environmental, social, and economic states and their potential impacts on commercially important fish species.

Develop statistically- or expert-based thresholds that link indicator level to action to improve reproducibility and transparency in how ecosystem-indicators could lead to adjustments in quotas

The main concern about using the proposed decision matrix is its lack of defined thresholds that link indicator levels to action. The proposed HCR (black line in Figure 7-2) is a conservative approach towards setting herring harvest guidelines that takes into account some of the ecosystem considerations of harvesting forage fish. The explicit ecosystem indicators chosen in the decision matrix make ecological sense, but there was concern raised that the qualitative nature of the decision-making approach as it is proposed is not based on strong enough scientific links between a given indicator, the ecological response, and the proposed quota adjustments and could lead to criticism and unexpected outcomes. In turn, the review panel recommends developing limits to allow reproducibility and transparency in how ecosystem indicators could lead to adjustments in the proposed quotas to accomplish the goal that quotas can be adjusted by the CDFW's Director as needed without regulatory changes.

To then assist in linking ecosystem indicators to management action, the review panel suggests that CDFW could build a decision tree, that highlights at what established ecosystem thresholds HCR adjustments would be made. Other qualitative management indicators used for single species management, such as Productivity Susceptibility Analysis (Patrick et al., 2010), provide semi-quantitative scoring, and developing something analogous for the decision matrix would provide a transparent way to develop a score for the number of indicators that are low/medium/high within each of the broad categories, with a decision tree/table for when or how much quota would be reduced (or increased) given a certain ecosystem score. Table A5 does this for the Alternative Forage Indicators, but the other two components of the decision matrix (Herring Productivity and Predator Indicators) do not have a scoring system developed. Additionally, having a sense of how past conditions would score under any threshold would be useful to make sure that the tool is performing as expected.

An additional approach towards setting thresholds and decision rules could be to incorporate stakeholder involvement while setting the thresholds and potential quota adjustments. For example, such an approach could mirror recent efforts (Draft Risk Assessment and Mitigation Program developed by the California Dungeness

Crab Fishing Gear Working Group) that have developed a framework based on objective criteria, including ecosystem thresholds, to assess whale entanglement risk by Dungeness crab gear. This process brings together a group of scientists, managers, and stakeholders to assess information including ecosystem conditions that can lead to low, medium, or high level of risk to whales. A similar approach for the San Francisco Bay herring fishery could be useful by gathering a diverse set of experts to inform thresholds and build stakeholder engagement and trust in the resulting thresholds.

Regardless of how ecosystem indicators are potentially incorporated into adjusting quotas, more description of the decision-making and stakeholder processes of moving from preliminary HCR to using ecosystem indicators to shift quota, such as a flowchart, would be a critical addition to the draft FMP.

Perform a retrospective analysis to examine how quotas would have been adjusted in past years

The review panel recommends performing retrospective analyses to examine how often quotas would have been adjusted in past years under proposed management scenarios. For example, which years and what overall percentage of time would the quota have been adjusted up or down based on past ecosystem conditions. This would help CDFW and the broader stakeholder community understand what role the ecosystem indicators would likely have in adjusting quota and would increase the transparency of the consequences of choosing an updated quota based on the ecosystem conditions.

Provide additional evidence linking ecosystem indicators to specific ecological responses

While the ecosystem indicators seem logical, the reviewers would like to see additional documentation of studies linking each indicator to ecological impacts, and a discussion of the degree of confidence in that inference. Based on how indicators are related, composite forage indices or decision trees linking conditions of multiple indicators may be appropriate to consider.

Some technical questions about the indicators remain, for example:

- Is it desired to use indicators that are NOT correlated, or would it be desirable that they are reflecting the same phenomenon and therefore several of them would provide greater weight of evidence that that particular phenomenon was occurring?
- The forage indicators for market squid and groundfish appear to reflect poor conditions only if also found in concert with low pelagics. This suggests a composite index might be more appropriate (or a decision tree where only consider squid and groundfish being low IF pelagics are also low).
- Also, given the uncertainty and lack of data on diets from the winter, weighting the forage indices by the number of predators in which the item appeared (as was the originally attempted weighting scheme) appeared to be arbitrary. Do we know if any of the predators actually specialize, or if they are generalist and likely prey switch? If the latter, then some sort of composite forage index might make sense, assuming all predators access it.

Conduct an MSE that more explicitly includes ecosystem indicators

An MSE that includes ecosystem indicators, perhaps in place of those relative to B_0 and B_{MSY} as performance metrics (as discussed in Section 2.2.2) could provide more information and help CDFW understand the impacts of ecosystem conditions on the fishery. For example, combining an MSE including ecosystem indicators with economic analysis could provide insight into whether the most extreme scenarios (i.e. HCR rules under best versus worst ecosystem indicators) are expected to have significant economic impacts.

Set more quantitative goals for the fishery

The review panel recommends setting more quantitative goals, or "targets," for the fishery. Many of the goals throughout the draft FMP are well stated qualitatively, but lack quantitative targets to measure against. In many cases, management can only react to stock fluctuations, rather than determine them by attempting to maintain biomass around some target. The San Francisco Bay Pacific herring stock seems to follow this sort of pattern—recruitment is largely environmentally driven. The balance to be struck in volatile fisheries like this is one between maintaining a fleet such that booms can be capitalized upon and a fleet small enough to weather periods of poor productivity. Without quantitative targets to measure against, it may be difficult to maintain management objectives.

4. SCIENCE SUPPORTING ADDITIONAL CONSERVATION AND MANAGEMENT MEASURES

The draft FMP describes the history and rationale for the management measures that have been employed in the California Pacific herring fishery. While quotas are the foundation for ensuring sustainability in Pacific herring stocks, the draft FMP describes the additional management measures CDFW employs to provide additional safeguards for the stock. These other management measures include: 1) effort restrictions (which include permit consolidation and fleet capacity limits), 2) gear restrictions, 3) spatial, temporal, and seasonal restrictions, 4) size and sex, 5) prevention of bycatch, and 6) reduction of habitat impacts.

Reviewers concluded that a sloped HCR with a 10% maximum exploitation rate is likely to minimize the impact of the fishery on both the stock and the ecosystem. Thus, using catch restrictions as the main management measure is likely to be effective, and streamlining the temporal regulations, as is proposed, so that all populations have the same start and end date will likely make this management measure more enforceable. The additional conservation measures are likely to further support sustainability of the San Francisco Bay stock and the review panel has only minor recommendations that should be addressed before adoption of the FMP.

4.1 Key recommendations

Provide further rationale for mesh size limits

Mesh limits are often a good idea, but there does not seem to be a quantitative approach for determining what is best included in the analysis. Data on the initial (160-170mm) and fully selected sizes (180-185mm) is given, but the review panel recommends a selectivity ogive, and explicit linkage age (using Figure 3-7) to inform how it relates to age-based selectivity goals.

Expand discussion of implications of targeting age 4+ on stock sustainability

While the recovery of herring age structure shown in Figure 6-2 suggests that the current mesh size is not resulting in major age truncation, targeting age 4+ may still result in evolutionary changes in growth, maturity, fecundity, and reproductive behaviors. Reviewers suggest adding discussion about the implications of this for stock sustainability.

Expand description of effort restrictions and its link to desired tonnage goals

An expanded narrative of the stakeholder process and the rationale for relating the number of permits to maximum quotas was provided to the reviewers by CDFW during the review and should be incorporated into the draft FMP.

Set more quantitative targets for when certain rules will be reconsidered

Some examples of vague, or difficult to evaluate, statements that would benefit from clear, quantitative targets include: "should conditions change in the future," "some changes to the season dates are warranted," and "should the recreational sector continue to grow." CDFW should work to develop thresholds that determine when these rules will be reconsidered.

5. FUTURE RESEARCH AND METHODS

The draft FMP is designed to provide a comprehensive and adaptive management strategy for the California Pacific herring fishery. To support this goal, the draft FMP identifies additional management needs and future research that would assist CDFW in improving assessments and management in the future. Throughout this report, reviewers have identified additional research and data needs that would support more robust management of the fishery, some of which are mirrored in the "Additional Management Needs and Future Research" chapter of the draft FMP. Recommended future research and data needs not already outlined in the draft FMP should be added to the relevant section before adoption.

Overall, as there is a wealth of data for the San Francisco Pacific herring population and the California Current Ecosystem, reviewers recommend prioritizing the synthesis of existing data and information before allocating resources to collecting additional data, except for recruitment data and in the scenario where anomalous conditions require additional data.

5.1 Key recommendations

Prioritize sampling for recruitment

As stated previously, reviewers commend the proposed SSB model and HCR for considering recruitment in setting annual quotas. This is a crucial improvement on the previous method for setting quota and should be prioritized in order for CDFW to successfully reach their management goals (also discussed in Section 1.1.4). If these data become unavailable, SSB estimates are not likely to be as accurate.

Formally analyze predator-prey interactions to inform incorporation of ecosystem indicators

A major component of the draft FMP is the ecosystem considerations, with a focus on predator-prey dynamics. This should likely be a future focus of research, with an aim to identify whether and when prey provide a limiting factor. Questions that should be answered include:

- Is there evidence that predator populations do fluctuate in response to the available forage (or that there is a cutoff below which predator indicators decline)?
- Is there any evidence that, when small pelagics are low in abundance, that abundant herring become a focal prey item or that there is prey overlap? For which predators?
- Are these the same predators that might show occasional prey limitation?
- Does the spatial distribution of predators, prey, and herring play a factor?

Diet analysis, historical analysis, and expert elicitation all might provide fruitful avenues to answer these questions. As noted in the draft FMP, the California Current Integrated Ecosystem Assessment has synthesized a number of indicators of forage, predator status, and ecosystem conditions, and many of these time series are available since the early or late 1990s. Incorporating these data further into the ecosystem decision matrix as well as a formal analysis of the linkage between forage fish and predators could improve the capacity and transparency of including the ecosystem considerations in the setting quotas.

Better characterize spatial variation in response to environmental change

At a minimum, coarse monitoring of stocks in other California locations may help understand whether stocks are responding differentially to environmental change. If it is to be used for this purpose, provide more detail about the Rapid Spawn Assessment Method, and its performance when applied to the relatively data-rich San Francisco Bay stock (as discussed in Section 1.1.3). Because the herring population in San Francisco Bay represents the southern end of their range, there is the possibility that increased temperature stress and/or range shifts may affect this population. As such, explicit monitoring of all California herring populations in response to environmental change should be on the radar for future monitoring or research. This understanding would allow the fishery management system to be more climate-ready.

5.2 Longer-term recommendations

Better characterize interannual spatial dynamics of stocks

Much of the concerns about ecosystem dynamics are complicated by spatial behavior before and after spawning. That is, where do herring go to feed, and what feeds upon them when they are away from spawning areas? Characterizing these dynamics might be a key future research endeavor to identify which ecosystem indicators should actually be considered given the spatial overlap of herring with their prey and predators. CDFW may consider using high resolution, polymorphic SNP markers that are now available (E. Petrou and L. Hauser, in prep) to evaluate spatial structure of the stock (as discussed in Section 1.2.1).

Better track, consider, and integrate recreational take into quota setting

As mentioned in the draft FMP, there is currently no data on the magnitude of catch in the recreational sector of the California Pacific herring fishery. Moving forward, it will be important for CDFW to quantify recreational catch so that it can be considered in setting quota. Currently, it is not clear how recreational take impacts the herring stock under the proposed HCR. Accounting for varying levels of recreational catch in an MSE and integration of this information, when available, will result in a more robust management strategy.

Identify external ecosystem factors that affect herring populations

What are the impacts of cumulative stressors (e.g. temperature together with water quality) on herring stocks? A broader MSE that takes into account external stressors will help identify where the HCR framework may fail.

Develop a sampling program to directly estimate maturity, fecundity, growth, and mortality

These demographic parameters may underlie the changes in size-at-age in San Francisco Bay. Knowing which of these drivers is operating can help identify appropriate management action to counteract these effects.

References

Department of Fisheries and Oceans. 2015. Stock assessment and management Advice for BC Pacific herring: 2015 status and 2016 forecast. Canadian Science Advisory Secretariat Science Rasponse 2015/038.

Department of Fisheries and Oceans. 2017. The selection and role of limit reference points for Pacific herring (*Clupea pallasii*) in British Columbia, Canada. Canadian Science Advisory Secretariat Science Response 2017/030.

Harvey C, Garfield N, Williams G, Andrews K, Barceló C, Barnas K, Bograd S, Brodeur R, Burke B, Cope J, deWitt L, Field J, Fisher J, Greene C, Good T, Hazen E, Holland D, Jacox M, Kasperski S, Kim S, Leising A, Melin S, Morgan C, Munsch S, Norman K, Peterson WT, Poe M, Samhouri J, Schroeder I, Sydeman W, Thayer J, Thompson A, Tolimieri N, Varney A, Wells B, Williams T, and Zamon J. 2017. Ecosystem status report of the California Current for 2017: A Summary of ecosystem indicators compiled by the California Current Integrated Ecosystem Assessment Team (CCIEA). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-139. https://doi.org/10.7289/V5/TM-NWFSC-139.

Hauser L and Petrou E. Unpublished data, University of Washington.

Hulson P-JF. 2007. Analysis and comparison of age-structured assessment models for two Pacific herring populations. Thesis. https://scholarworks.alaska.edu:443/handle/11122/5863.

Levin PS, Essington TE, Marshall KN, Koehn LE, Anderson LG, Bundy A, Carothers C, Coleman F, Gerber LR, Grabowski JH, Houde E, Jensen OP, Möllmann C, Rose K, Sanchirico JN, and Smith ADM. 2018. Building effective fishery ecosystem plans. Marine Policy. 92:48–57. doi:10.1016/j.marpol.2018.01.019.

Levin PS, Francis TB, Taylor NG. 2016. Thirty-two essential questions for understanding the social–ecological system of forage fish: the case of Pacific herring. Ecosystem Health and Sustainability. 2(4):e01213. doi:10.1002/ehs2.1213.

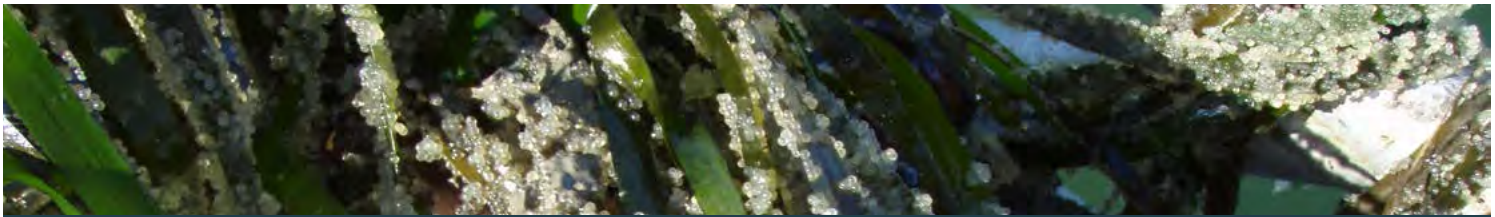
Martell SJ, Schweigert JF, Haist V, and Cleary JS. 2012. Moving towards the sustainable fisheries framework for Pacific herring: data, models, and alternative assumptions; stock assessment and management advice for the British Columbia Pacific herring stocks: 2011 assessment and 2012 forecasts. DFO Canadian Science Advisory Secretariat Science Response Doc. 2011/136. xii + 151 p.

Patrick WS, Spencer P, Link J, Cope J, Field J, Kobayashi D, Lawson P, Gedamke T, Cortés E, Ormseth O, Bigelow K, and Overholtz W. 2010. Using productivity and susceptibility indices to assess the vulnerability of United States fish stocks to overfishing. Fishery Bulletin 108:305–322.

Sydeman WJ, García-Reyes M, Szoboszlai AI, Thompson SA, Thayer JA. 2018. Forecasting herring biomass using environmental and population parameters. Fisheries Research. 205:141–148. doi:10.1016/j.fishres.2018.04.020.

Tanasichuk RW, Ware DM. 1987. Influence of interannual variations in winter sea temperature on fecundity and egg size in Pacific herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences 44(8):1485–1495. doi:10.1139/f87-178.

Thynes T, Coonradt E, Harris D, Walker S. 2018. 2018 Southeast Alaska sac roe herring Fishery Management Plan. Alaska Department of Fish and Game, Division of Commercial Fisheries,. Regional Information Report 1J18-02, Douglas.



Appendix A: Terms of Reference

1. Introduction

1.1 CDFW Management Context

Pacific herring populations support important commercial and recreational fisheries in California state waters. Herring are a schooling species found throughout California nearshore ecosystems during spring and summer and migrate to bays and estuaries to spawn from November through April. They play an important role in the California marine ecosystem as a forage species for a wide suite of predators, including marine birds and mammals and are among the top forage species in terms of their proportion in predator diets, making them an essential food source for predators on the West Coast. The San Francisco Bay herring population supports a valuable fishery for herring roe (kazunoko), and a smaller herring-eggs-on-kelp (komochi or kazunoko kombu) fishery. San Francisco Bay also supports a limited commercial fresh fish and recreational fishery.

A primary goal of fishery management under the Marine Life Management Act (MLMA) is to ensure that fishing levels are sustainable and do not result in an overfished stock. While the commercial herring fishery is considered well managed, even with a very precautionary management approach, concerns about changing ocean conditions, sea-level rise, loss of spawning habitat, stakeholder interest, and a need to better understand spawning and stock fluctuations and their role as a forage fish have prompted the development of a fishery management plan (FMP). FMPs assemble information, analyses, and management options to guide the management of the fishery by the California Department of Fish and Wildlife (CDFW) and Fish and Game Commission (Commission). The FMP becomes effective upon adoption by the Commission, following their public process for review and revision. Thus, it is important for the scientific underpinnings of the draft FMP to have undergone independent review prior to submission to the Commission. External, independent peer review of the scientific underpinnings of the FMP is one way to provide the Commission and stakeholders assurances that the FMPs are based upon the best readily available scientific information, as set forth under the MLMA. The Ocean Protection Council (OPC) has provided funding to complete the peer review process for the Pacific herring FMP.

1.2. Review Process Goals and Objectives

Ensuring the best use of best available information in fisheries management is an important tenet of the MLMA. The MLMA identifies external scientific review as a key tool to ensure management decisions are based on the best available scientific information. CDFW is committed to incorporating the best available scientific information into fisheries management through a peer review process.

Scientific and technical peer review (review) is widely applied across numerous technical disciplines to assure products are of high quality, reflect solid scholarship, and that the information contained is accurate and based on rigorous, sound scientific methods (OST 2016). In any review, Ocean Science Trust's (OST) intent is to provide an assessment of the work product that is balanced, fairly represents all reviewer evaluations, and provides feedback that is actionable. When building a review process, OST seeks to balance and adhere to six core review principles: scientific rigor, transparency, legitimacy, credibility, salience, and efficiency. These principles ground the review and shape the products that we develop.

As such, the goals and objectives of the FMP review process are to:

1. ensure that the science underpinning the FMP represents the best available scientific information and is appropriately used to inform a harvest control rule;
2. follow a detailed calendar and fulfill explicit responsibilities for all participants to produce required reports and outcomes;
3. provide an independent external scientific and technical review of the agreed upon sections of the herring FMP;
4. use review resources effectively and efficiently.

1.3. Review Coordinating Body: Ocean Science Trust

Ocean Science Trust is an independent non-profit organization working across traditional boundaries to bring together governments, scientists, and citizens to build trust and understanding in ocean and coastal science. We empower participation in the decisions that are shaping the future of our oceans. We were established by the California Ocean Resources Stewardship Act (CORSA) to support managers and policymakers with sound science.

For more information, visit our website at www.oceansciencetrust.org.

Contact information

Jessica Williams, California Ocean Science Trust (jessica.williams@oceansciencetrust.org)

2. FMP Peer Review Scope and Process

2.1 Review Request

CDFW's purpose in asking for this review is to ensure the scientific and technical elements presented within the FMP provide a rigorous underpinning for management decisions and regulatory action. Ocean Science Trust is serving as the review coordinating body, and worked with CDFW to develop a scope of review that focuses on key scientific and technical components of the FMP where independent scientific assessment would add value (this document). The review is not intended to be a comprehensive assessment of the entire FMP or the proposed approach to management contained therein, but rather focuses on key components identified below. Components subject to review were determined using criteria from OST 2017 (here).

2.2 Scope of review

CDFW is seeking an independent assessment of the science underpinning the proposed management framework that will guide fishery management decisions for the San Francisco Bay Pacific herring stock. The framework uses a predictive model for determining herring spawning stock biomass mass and data collected by CDFW and others in the California Current Ecosystem. The review will focus on whether the available data and predictive model that underpin the proposed FMP management strategy are applied in a manner that is scientifically sound, reasonable, and appropriate.

The central question of this review is:

Given CDFW's available data streams and analysis techniques, are the applications of the analyses to the integrated management strategy scientifically sound, reasonable and appropriate?

Specifically, the review will focus on evaluation of the following components of the FMP:

- the accuracy of representation of existing literature on the biology of the stock and in the essential fishery information (Sections 3 and 5.2)
- the proposed spawning stock biomass thresholds and associated harvest rates underpinning the catch quota decision making process and signaling when the fishery may warrant management response; (Section 7.7)
- the decision matrix of ecosystem indicators and the rationale behind the inclusion of these ecosystem indicators in management; (Section 7.7)
- the science underpinning additional conservation and management measures (Section 7.8)
- identify research and methods needed to improve assessments and fishery management in the future (Section 8)

For clarity we note that the following are not included in the scope of the current review:

- the data collection protocol (Section 5.1), as it has been reviewed previously
- the new predictive model for spawning stock biomass (Section 7.6), as this is currently undergoing a separate peer review.

2.3 Process

Review Process Overview

- **Select a review mode.** A review process is selected in consultation with CDFW and the Ocean Protection Council by considering complexity, management risk, uncertainty, socioeconomics, level of previous review, and novelty (OST 2016; OST 2017).
- **Assemble review team.** Ocean Science Trust will convene a 3-4 member review panel composed of Ocean Protection Council Science Advisory Team members and other experts (see "Assembling a Review Team," OST 2016 and "assembling a review team" below for additional details).
- **Conduct review via a series of webinars.** Group webinars will allow CDFW to engage directly with reviewers at the outset to present the inputs, model methods, and application of analyses and provide two-way interaction to provide any additional clarity needed to complete the review. There will also be opportunities for independent deliberation and conversation among reviewers.
- **Develop and share final report.** Reviewers will contribute to the development of a final report, which will be made available on the OST and CDFW webpages.

Review Mode: Remote Panel Review

All meetings will take place via remote online meetings (webinars). At the outset of the review, OST will work with CDFW to develop detailed reviewer instructions that encourage focused scientific feedback throughout the process. Instructions will include directed evaluation questions and may delegate tasks for reviewers based on their individual areas of expertise. This document will be used to guide the development of meeting agendas and track progress throughout the course of the review. For each meeting, advance work will be required of participants (e.g. drafting responses to guiding questions) in order for all parties to come prepared for meaningful discussions. OST will notify CDFW of additional requested materials and data immediately following the first webinar.

Webinar 1: Initiation of Review

Ocean Science Trust will host an initial webinar to provide the review committee and CDFW staff an overview of the scope and process, and clarify the roles and responsibilities of each participant. CDFW will also provide a summary of the relevant management context to ensure reviewers understand the role of the review in the larger FMP development process, and how the outputs will be considered. The bulk of the webinar will then focus on a presentation by CDFW and FMP contractor on the scientific and technical components of the draft FMP. This webinar is an opportunity to develop a shared understanding of the tasks and allow reviewers to ask CDFW any clarifying questions about the review materials before they convene independently to conduct their technical assessment.

Webinar 2-3: Reviewers convene with OST to conduct review

Ocean Science Trust will convene approximately two remote one- to two-hour webinars with the review committee to conduct an in-depth evaluation of the components identified in the Scope of Review (above). In advance of each webinar, reviewers will be asked to prepare responses to guiding evaluation criteria questions specified in the review instructions. During each webinar, reviewers will discuss their findings and develop conclusions and recommendations within the context of these questions. Additional follow-up phone conversations may be scheduled as needed to complete the review. Outputs from each webinar, as well as reviewer responses to the questions, will guide the development of the final report.

Webinar 4: Final summary report feedback

Ocean Science Trust will host a final 1-hour webinar to gather final feedback and input from the review panel on the summary report. The review panel will be asked to review the draft summary report in advance of this meeting. This final meeting will provide a space for reviewers to voice any suggested edits or clarifications, and a chance to have a final discussion about results before sharing the final report with CDFW.

Management Preview

Ocean Science Trust will share the final summary report with CDFW for a management preview before the review results are published. There will be an opportunity for CDFW to ask clarifying questions of the review committee and for reviewers to make clarifying edits, as appropriate. This may occur via email, conference call or short webinar as time allows.

Assembling Reviewers

Transparency

Reviewer names will be published on OST's webpage for the review at the outset of the review; however, specific review comments in the final review report will not be attributed to individual reviewers.

Selection of Reviewers

Ocean Science Trust will implement a reviewer selection process to assemble a review committee composed of 3-4 external scientific experts. Ocean Science Trust will consult with and solicit reviewer recommendations from CDFW, the OPC-SAT, as well as OST's own professional network among the academic and research community. Membership may include experts from academia, research institutions, and government agencies as appropriate to deliver balanced feedback and multiple perspectives. Reviewers will be considered based on three key criteria:

Expertise: The reviewer should have demonstrated knowledge, experience, and skills in one or more of the following areas:

- Fisheries biology, stock assessments and modeling, including spawning stock biomass analyses and application
- Herring and/or forage fish biology and ecology, with an understanding of California's coastal ecosystem and how forage fish stocks and linked populations (e.g. predators) respond to fishing pressure and climate change
- Developing and/or testing harvest control rules for fisheries management, including applying ecosystem based management

Objectivity: The reviewer should be independent from the generation of the product under review, free from institutional or ideological bias regarding the issues under review, and able to provide an objective, open-minded, and thoughtful review in the best interest of the review outcome(s). In addition, the reviewer should be comfortable sharing his or her knowledge and perspectives and openly identifying his or her knowledge gaps.

Conflict of Interest: Reviewers will be asked to disclose any potential conflicts of interest to determine if they stand to financially gain from the outcome of the process (i.e. employment and funding). Conflicts will be considered and may exclude a potential reviewer's participation.

Final selections for the review committee will be made by the OPC-SAT Executive Committee. Ocean Science Trust will select one member of the review committee to serve as chair to provide leadership among reviewers, help ensure that all members act in accordance with review principles and policies, and promote a set of review outputs that adequately fulfill the charge and accurately reflect the views of all members.

Transparency in the Review Process

To ensure transparency, reviewers will serve openly. Reviewer names will be published on Ocean Science Trust's review webpage at the outset of the review. However, to encourage unbiased and candid input, specific review comments will not be attributed to individual reviewers. Upon delivery of the final report to CDFW, the report will also be made public on the OST review webpage.

In addition, OST will host a public webinar briefing in which the review committee, led by the chair, will share the draft findings of the review process. The information sharing will be open to the public, and include a Q&A so the reviewers (and CDFW scientists) can answer questions. This meeting will occur after the completion of the final summary report.

2.4 Review Report (reference appendix template)

Ocean Science Trust will work with reviewers to synthesize reviewer assessments (responses to the review instructions and input during webinars) into a cohesive, concise final written summary report. This review summary will be delivered to CDFW by late September 2018, and made publically available on OST's website. Reviewers may also provide individual in-text comments on the draft FMP which will be provided to CDFW for internal use. We acknowledge that reviewers may provide scientific recommendations beyond the given reviewer charge; such scientific recommendations will be honored and represented in the final summary.

2.5 Timeline

The review will commence in February 2018 with the expected delivery of a final summary report to CDFW in October 2018. A timeline is provided below.

Milestone	Feb	Mar	April	May	June	July	Aug	Sept	Oct
Review Preparation									
Develop and Finalize Terms of Reference	X	X							
Establish review panel		X	X						
CDFW delivery of draft FMP to Ocean Science Trust				X					
Conduct Review									
Webinar 1: Initiation of review				X					
Webinar 2: Essential Fishery Information; Spawning stock biomass thresholds; Additional management measures				X					
Webinar 3: Ecosystem indicators matrix; Future research methods						X			
Webinar 4: Final discussion and report feedback							X		
Finalize Summary Report									
Final report available online									X
Public sharing webinar with review panel members									X

3. Roles and Responsibilities of Peer Review Participants

3.1 Shared Responsibilities

All participating parties share the responsibility in assuring adequate technical and scientific review of the Pacific Herring FMP in accordance with the MLMA.

3.2 Reviewer Responsibilities

The role of the review committee is to conduct a detailed evaluation of the scientific underpinnings of aspects of the Pacific Herring FMP where external review will be valuable. The specific responsibilities of the review committee are included in the Review Instructions. The review committee may request additional information, data, and analyses as appropriate to support a comprehensive and useful review.

The review committee chair has, in addition, the responsibility to: 1) provide leadership among reviewers; 2) ensure that review committee participants follow the terms of reference and review instructions and guidelines; and 3) promote review outputs that adequately fulfill the charge and accurately reflect the views of all members.

The review committee is required to make an honest and legitimate attempt to resolve any areas of disagreement during the review process. Occasionally, fundamental differences of opinions may remain between reviewers that cannot be resolved. In such cases, the review committee will document the areas of disagreement in the final summary report.

Selected reviewers should not have financial or personal conflicts of interest with the scientific information, subject matter, or work product under review within the previous year (at minimum), or anticipated. Reviewers should not have contributed or participated in the development of the product or scientific information under review. Review committee members who are federal employees should comply with all applicable federal ethics requirements. Reviewers who are not federal employees will be screened for conflicts of interest.

3.3 CDFW FMP and Management Team Responsibilities

The Mission of the California Department of Fish and Wildlife is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. CDFW and the management team, including contractors, will participate in the review process as follows:

1. *Provide all relevant project documents, data, and supporting materials.* CDFW will identify and provide all project documents, data, and other information necessary for reviewers to conduct a constructive assessment. CDFW will work to ensure all related materials are clear and accessible to reviewers in a realistic timeframe and respond to additional requests in a timely manner.

2. *Constructively engage with reviewers and OST staff, and respond to data and other information requests in a timely manner.* CDFW staff and contractors most familiar with the draft FMP will engage in the process and be available to answer questions or present materials to the review committee as necessary. The CDFW Environmental Scientist, Ryan Bartling, and contractor, Sarah Valencia, have agreed to serve as the primary contacts during the review process. In order to adhere to review timelines, CDFW will respond to and provide feedback on requested materials from OST in a reasonable, mutually agreed-upon timeframe.

3. *Consider reviewer comments and recommendations.* CDFW intends to consider and incorporate reviewer feedback and recommendations into the FMP and supporting materials as appropriate.

3.4 Ocean Science Trust Responsibilities

California Department of Fish and Wildlife has requested OST to serve as the independent appointed entity to design and coordinate all aspects of this scientific and technical review. Ocean Science Trust will design and implement all aspects of the review process to meet management needs, including assemble and guide a committee of expert reviewers, conduct a review process that is on task and on time, schedule and host remote meetings as appropriate, work with reviewers to produce a written final summary report, and encourage candor among reviewers, among other activities. Upon completion of the review, the final report will be delivered to CDFW and made publicly available on the OST website. Throughout, OST will serve as an honest broker and facilitate constructive interactions between CDFW and reviewers as needed in order to ensure reviewers provide recommendations that are valuable and actionable, while maintaining the independence of the review process and outputs.

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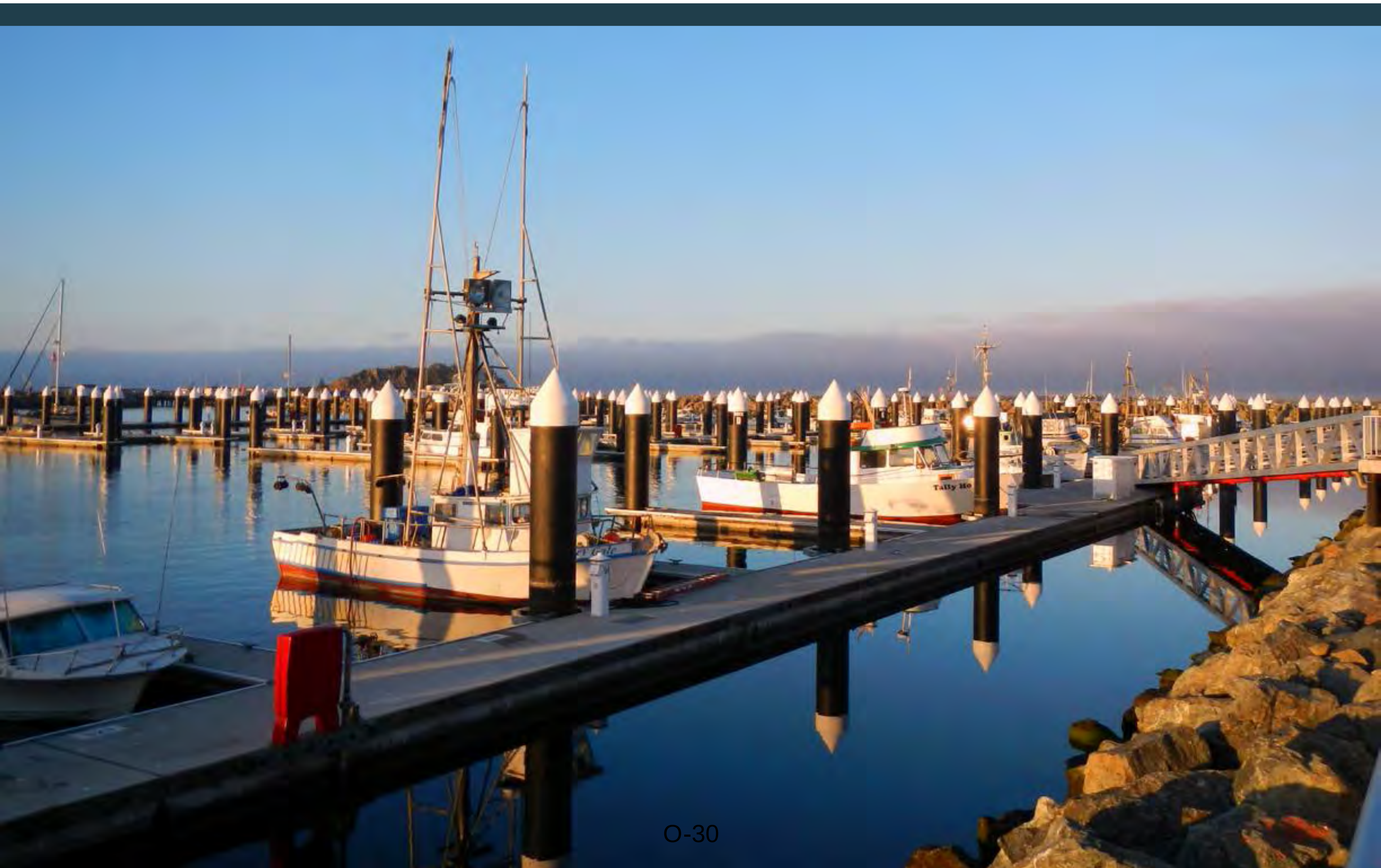

Appendix P Description of Rapid Spawn Assessment

As described in Section 7.5 of the FMP, the Tier 2 management strategy is designed to scale the amount of monitoring required by the Department to the level of fishing effort that occurs in an area. When a management area is assigned to Tier 2, fishing may occur at a precautionary quota level (1.5-3% of historical SSB for that area or 50% of historical average catch for Crescent City Harbor). At a minimum, in Tier 2 management areas catch must be monitored via fishery-dependent monitoring protocols (Section 7.5.1). However, fishery-independent monitoring may also be conducted. Traditionally, fishery-independent monitoring protocols for Pacific Herring (Herring), *Clupea pallasii*, have relied on Spawning Stock Biomass (SSB) estimates derived from spawn deposition and midwater trawl surveys. This provides the most informative indicator of stock status but is costly and labor-intensive (Chapter 6). This level of annual monitoring effort is not necessary for the highly precautionary Tier 2 management areas and likely cannot be achieved at current staffing levels. Instead, the Department of Fish and Wildlife (Department) will apply a less intensive Rapid Spawn Assessment (RSA) approach using information on Herring population spawning characteristics to monitor if Tier 2 management areas remain consistent with sustainable fisheries management. In addition to fishery-independent monitoring provided by the RSA, any quota increase in Tier 2 management areas will require a single-season SSB estimate based on a full spawning deposition survey (Section 6.1.2.1). This reduces the potential risk associated with adjusting quotas and is consistent with the precautionary Tier 2 management approach.

Rapid Spawn Assessment

Department staff have been exploring RSA protocol in Humboldt Bay with the following objectives: 1) identify spawn frequency and timing, 2) identify spawn location and spatial extent, and 3) qualitatively categorize the density of each spawn as high, medium, or low.

The annual frequency (number) and spatial extent (total area) of spawning events within a management area can be used as a course indicator of spawning population condition. Independently, or in association with timing, location, and qualitative spawn density estimates, this data can be compared with historical information and used to track changes in spawn behavior characteristics from year to year. This method can identify potential problems in spawning populations that may warrant more precaution, such as the closure of the fishery, or additional research. For example, significant decreases in the frequency and/or spatial extent of spawning events in a management area may indicate declines in the spawning population. Similarly, sustained shifts in spawn timing, location, or qualitative estimates of spawn density may indicate changes to the spawning population that warrant further research and evaluation. The goal of the RSA is to provide Department staff with a less labor-intensive way to monitor if Herring stocks in Tier 2 management areas can continue to support the precautionary quotas, and to make adaptive management changes as needed.

Identifying Spawning Events (Frequency)

This monitoring procedure requires being able to effectively detect spawning events. Searching for Herring spawn events is time consuming; however, the Department will continue to collaborate with commercial fishermen for assistance with spawn reporting as well as engage other interested stakeholders (see the section on Opportunities for Collaborative Research).

Delineating Spawning Area (Spatial Extent)

Herring spawn in different habitat types, which, in California, can be broadly classified as intertidal shoreline and water-bottom vegetation. The sampling protocols to delineate spawning area for these habitat types are described in the following sections.

Water-bottom Vegetation Spawns

In Humboldt, Tomales, and San Francisco Bays, intertidal and subtidal beds of vegetation (primarily *Zostera marina* and *Gracilaria* spp.) provide significant spawning habitat for Herring. In these areas, the spatial extent of spawn is delineated from a boat. Rake samples of vegetation are systematically taken on a pre-determined regularly spaced grid and visually evaluated for the presence/absence of Herring eggs. The edges of the spawning area can be identified by the consistent absence of eggs on rake samples or topographical features identifying the boundary of the vegetation bed. The boundary of the spawning area is mapped using GPS/GIS to estimate the spatial area of the spawn.

Intertidal Shoreline Spawns

In Crescent City Harbor and San Francisco Bay, Herring commonly spawn on intertidal shorelines. These spawning events can occur on natural shorelines or on manmade structures in the intertidal zone such as riprap and pier pilings. Spawns deposited on natural or riprap intertidal areas are primarily surveyed from land, although in some cases they can be surveyed from a boat. The boundary (length and width) of the spawning area along the shoreline is mapped using GPS/GIS to estimate the spatial area of the spawn. Overall width of the spawn may be estimated by taking the average of several width measurements over the length of the spawn. Surveying spawn deposited on pier pilings is conducted from a boat. The average area of spawn covering each piling is calculated and multiplied by the number of pilings on which spawn was deposited.

Qualitative Assessment of Spawn Density

Qualitative estimates of spawn density can provide useful information to assess spawning population behavior when combined with spatial extent and frequency of spawns. Egg deposition density is observed from multiple spatially balanced points throughout each spawn. Using these observations and historical quantitative observations of spawn density in the management areas, spawns can be visually categorized as low, medium, or high density.

Monitoring Summary

At the end of the spawning season, ahead of the Director's Herring Advisory Committee meeting, the Department will develop a monitoring summary to be included in the Pacific Herring Enhanced Status Report for all actively fished Tier 2 management areas. The monitoring summary will include the results of all fishery-dependent and fishery-independent monitoring activities conducted within the Tier 2 management areas during the season. The available information will be used to assess if the precautionary Tier 2 management quotas remain consistent with sustainable fishery management or if additional precautionary action should be taken.

Collaborative Research Workshop

While it is the responsibility of the Department to monitor fish stocks, the Department is limited by staffing and resource constraints, and must allocate sampling efforts to areas where there is the most need. However, there are several opportunities for collaboration with various stakeholders, and these may provide additional information that can help inform management. In May 2018, a workshop was held to discuss opportunities and barriers to expanding collaborative research efforts. There is a history of collaborative research in the Herring fishery, and so permittees and Department staff were invited to share their experiences by describing how various research projects were structured, the types of data collected, management outcomes, research costs, and the administrative process. Some of the key outcomes of this workshop are summarized below, and were used to identify increased opportunities for collaborative research moving forward:

- Successful collaborative research depends on strong relationships between Department staff and stakeholders.
- From the Department's perspective, the most useful information stakeholders can provide is the location and time of an observed spawn, because searching for spawns is very time consuming. Both consumptive and non-consumptive stakeholders could provide this information.
- Other types of gear, such as lampara nets, allow fishermen to take a small but unbiased sample of a Herring school. This can produce useful information on the composition of the stock (age, length, weight, and sex structures).
- Economic incentives or outside funding to offset costs are necessary for collaborative research.

Opportunities for Collaborative Research

The efficacy of the RSA methodology will be greatly aided by collaboration with fishermen. First, Department staff will ask fishermen to notify staff when they observe Herring spawning activity (time and location of spawn) on a voluntary basis, whether they are fishing or not. One of the most time-consuming activities for the Department is searching for Herring spawns in the bays. This will provide more eyes on the water and increase the likelihood that spawns are detected, and their spatial extents assessed. While notifications of spawning events are purely voluntary, there is an incentive for fishermen to report spawns because low numbers of spawns or low total spawning area compared to historical data may indicate problems with the spawning population that could initiate a closure of the fishery. The Department may also be able to work with other stakeholders, such as birders or other non-consumptive users who are routinely out on the water or near shorelines. This will require Department staff to reach out to representatives from these groups and explain the need for spawn reporting and provide contact information to build a network.

Fishermen and other stakeholders may also be able to assist the Department through the collection of additional data on spawn size and density. This type of data collection will require volunteers going into the field to help Department staff map the sizes of spawns and potentially qualitatively assess spawning density. Such voluntary assistance may enable Department staff to more effectively monitor spawning events occurring in different locations at the same time.

Fishermen may be able to assist the Department with taking samples of whole Herring as well. Regulatory language developed in this FMP promotes greater participation. Using letters of authorization, Department staff may issue small individual quotas to permitted fishermen and allow whole Herring to be taken using a specified gear type in specific locations and timeframes. One of the key outcomes of the workshop was a recognition that other gear types such as lampara nets are more appropriate for taking small samples from Herring schools. These nets often have a smaller mesh size, and thus select a greater proportion of the population than variable mesh research gill nets, which can provide a less biased sample of the size or age structure of the stock. Additionally, lampara nets allow for a small sample to be taken quickly and the rest of the netted fish to be returned to the water unharmed.

Appendix Q Fishery Management Plan Scoping Process, Stakeholder Involvement, and Public Outreach

The Marine Life Management Act requires that the California Department of Fish and Wildlife (Department) involve the public in Fishery Management Plan (FMP) preparation. The Department's 2018 Master Plan for Fisheries directs the level of stakeholder engagement to be tailored to the size of the fishery and the complexity of the management changes under consideration. This document describes the ways in which outreach targeted key stakeholder groups to solicit stakeholder involvement in the development of the Pacific Herring (Herring), *Clupea pallasii,* FMP, as well as how this feedback was incorporated to create the proposed management strategy.

Steering Committee

The development of the Herring FMP provided an opportunity to test a new model of FMP development in which a small group of stakeholders representing various interest groups worked with Department scientists and managers to develop a vision for the Herring FMP, provide guidance throughout the FMP process, and communicate the goals and strategies of the plan to their wider communities. The goals of this approach were to solicit stakeholder input early in the process, give an opportunity for stakeholders to understand the results of the various scientific analyses being conducted, and make the overall process more interactive in order to reduce controversy during FMP development and implementation. The Steering Committee (SC) was formed out of an informal discussion group that began meeting in 2012 to discuss the management needs of the Herring fishery. This group, which included Herring fleet leaders, representatives from conservation non-governmental organizations (NGOs), and Department staff developed a "blueprint" outlining the broad scope and goals for the FMP development process, as well as the scientific analyses required to meet those goals.

It was agreed that the desired goal of the FMP development process was to develop a management plan that had the support of all SC members to the extent possible. To facilitate this, regular meetings were held with the SC to provide updates on progress and receive guidance on how to develop key elements of the FMP. Throughout the process the Department retained authority over the final contents of the FMP, and approval of an FMP for submission to the California Fish and Game Commission (Commission).

Public Scoping Process

When FMP development was initiated the first step of the process was to draft a document describing the intended scope of the project to alert stakeholders of the management issues to be addressed. The scope was based on the blueprint developed by the SC. This scoping document was then distributed to the public by various means, including a mailing to current Herring permit holders, posted on the Department's Marine Management News and Pacific Herring Management News websites, via email to the Director's Herring Advisory Committee (DHAC) members and to the interested parties email list.

The Department received 22 comments from the public in response to the release of document describing the intended scope of the project. The majority of the responses (15) were requests to be added to the email list. Of those respondents that listed their affiliation, eight were past or present commercial fishermen and six were from representatives of environmental NGOs or natural resource management agencies.

The comments from environmental interests expressed a desire to see the role of Herring as forage fish and climate change addressed in the FMP. The comments from current and past fishermen expressed concern about the cost of obtaining a Herring permit and the barriers to entry by new fishermen, the cost of a commercial fishing license in years when the respondent elected not to fish, the effects of fishing in Tomales Bay on the Herring population, and a desire to use round-haul (purse-seine) nets to fish for Herring. The SC discussed these concerns, and it agreed that the ecosystem role of Herring, climate readiness, barriers to entry, permit fees and requirements, and management of the Tomales Bay Herring population would all be addressed within the FMP development process. However, after much discussion it was decided that due to concerns about the environmental impacts and the increased analytical and stakeholder process required to develop a management procedure that included round haul gear, the Department would not be considering a gear change as part of the FMP process but would provide analysis under Project Alternatives within the FMP.

Pursuant to CEQA § 21080.3.1, as well as the Department's Tribal Communication and Consultation Policy, the Department and Commission provided a joint notification to tribes in California. The letters to the individual tribes were mailed on August 1, 2018. The Commission received a response confirming that the proposed project is outside of the Aboriginal Territory Stewarts Point Rancheria Kashia Band of Pomo Indians. The Indian Canyon Band of Costanoan Ohlone People requested a Native American Monitor and an Archaeologist be present on site at all times if there is to be any earth movement within a quarter of a mile of any culturally sensitives sites. The Department confirmed the project does not involve any earth movement within a quarter mile of any culturally sensitive sites.

The Department initially informed tribes that a FMP for Herring was being developed in a letter dated July 5, 2016. As a follow-up to the initial introduction by mail, Department staff met with Graton Rancheria staff per requested on September 20, 2016 to provide additional details on the FMP process and scope. A subsequent letter soliciting tribal input on the management objectives outlined in the FMP was mailed to tribes on March 28, 2018.

The results of the scoping process were presented to the Commission's Marine Resources Committee (MRC) at a public meeting in March 2017 for guidance and support for the intended scope of the FMP. The MRC adopted the intended scope which then guided the remainder of the FMP development process.

Commercial Permit Holder Meetings and Survey

Each year the Department meets with the DHAC, which is a group of industry representatives from various sectors of the fishery. At these meetings, Department scientists provide an overview of catch data (research and commercial) and provide the estimated spawning biomass during the season. It also provides an opportunity to discuss with DHAC members the Department's recommended quota for the next commercial Herring season. During the FMP development process these meetings provided additional opportunities to provide updates on the progress of the FMP. While these meetings focused primarily on changes affecting the San Francisco Bay gill net sector, additional one-on-one meetings were also held with representatives of smaller sectors of the fleet (in particular the Herring Eggs on Kelp (HEOK) sector and the northern gill net permit holders) to ensure that the needs of these sectors were being addressed in the FMP.

Additionally, the Department sought feedback from the Herring fleet on potential regulatory changes via a survey (Appendix Q). The survey was mailed to all permit holders, and could be returned via mail, email, or online. Based on the survey results, the Department worked with the Herring FMP Project Management Consultant Team to develop a draft proposal for regulatory changes that had broad support. A meeting for all permit holders was held in January 2018 (during the Herring season to maximize attendance), and the draft regulatory change proposal and management plan for setting Herring quotas were presented to the fleet. At this meeting permit holders had the opportunity to ask questions and provide comments back to Department staff and the Herring FMP Project Management Consultant Team. The meeting was also broadcasted via webinar to enable remote participation. The feedback from permit holders was recorded and discussed at the next SC meeting and used to refine the regulatory change proposals.

Fish and Game Commission and Marine Resource Committee Meetings

At the April 13, 2016 Commission meeting in Santa Rosa the initiation of the development of the Herring FMP was announced, and the Herring FMP Project Management Consultant Team to assist the Department were introduced. Short presentations were provided at subsequent MRC meetings to inform commissioners about the intended development process and to provide status updates. On July 21, 2016 a presentation was given to describe the overall goals and timeline for FMP development, as well as the public notification process, which was ongoing at that time. The results of the public scoping process were shared at the March 23, 2017 MRC meeting as well as the intended scope of the FMP. To support the development of a management strategy, a presentation providing an overview of the analyses underway was given at the July 21, 2017 MRC meeting. At the March 6, 2018 MRC meeting a more in-depth presentation was given to describe the core pieces of the proposed management strategy, including development of a Harvest Control Rule (HCR) framework, which accounts for ecosystem needs and a collaborative research protocol. At the July 17, 2018 MRC meeting, a presentation was given to provide updates on FMP development, including conducting an external peer review coordinated by California Ocean Science Trust, and updates on the HCR framework, collaborative research, regulations and permitting, and timeline. At each of these meetings members of the public were given the opportunity to ask questions and/or provide comments. All comments were recorded and discussed with the SC. Lastly, the Commission requested a presentation at the March 20, 2019 MRC to provide an update on the commercial Herring fishery catch and participation over time, and FMP updates including peer review recommendations, and the agreed HCR framework.

Public Meetings and Opportunities for Public Comment

Throughout the FMP development process, the public has been able to submit questions or comments to the Department staff via email or phone. In addition, public meetings were held in Sausalito, California, a number of times to share information with the public and provide an opportunity for interested parties to ask questions or provide comment. A public meeting was held in Sausalito in April 2016 to announce the initiation of the Herring FMP and to allow the public to ask questions. Once a management strategy was developed and agreed upon by the SC, that strategy was presented at a public meeting in Sausalito in January 2018. The meeting was filmed and posted online so people who were unable to attend could learn about the proposed management changes. The meeting had broad attendance and included commercial permit holders, recreational fishers, agencies and NGOs. One hour was allocated for comments and discussion. The feedback received, particularly from the recreational sector, was considered when developing the final regulatory proposal.

Notice of Preparation and Scoping Meeting for CEQA Process

On August 17, 2017, the Commission filed a Notice of Preparation (NOP) with the State Clearinghouse pursuant to the California Environmental Quality Act (CEQA). The NOP included a copy of the Initial Study pursuant to CEQA. On August 25, 2018, the Department held a scoping meeting to alert the public that the Initial Study, detailed project description, and a preliminary analysis of the environmental impacts was available for review. The meeting was publicized using the Herring FMP email list, on the Herring Management News and Marine Management News websites. The meeting provided an opportunity for interested stakeholders to ask questions and provide feedback on what environmental impacts they were most concerned about. The public was also encouraged to submit comments by email or mail between August 17, 2018 and September 21, 2018 (CEQA public comment period). Richardson Bay Regional Agency staff attended the meeting, and asked questions about impacts on eelgrass habitat in Richardson's Bay from non-fishing activities and to better understand the scope of the FMP. Environmental Action Committee of West Marin submitted a comment by email requesting that the Department consider direct and indirect environmental impacts to the Herring fishery and other fisheries, to wildlife including bird species, marine mammals and changing climate conditions.

Print Form

Appendix C

Notice of Completion & Environmental Document Transmittal

Mail to: State Clearinghouse, P.O. Box 3044, Sacramento, CA 95812-3044 (916) 445-0613
For Hand Delivery/Street Address: 1400 Tenth Street, Sacramento, CA 95814

SCH #

Project Title: Pacific Herring Fishery Management Plan (FMP) and Regulatory Amendments

Lead Agency: California Fish and Game Commission
Contact Person: Ryan Bartling (CDFW)
Mailing Address: P.O. Box 944209
Phone: (707) 576-2877
City: Sacramento
Zip: CA
County: Sonoma

Project Location: County: Multiple (see attachment)
City/Nearest Community: Various
Cross Streets: n/a
Zip Code:
Longitude/Latitude (degrees, minutes and seconds): ___° ___′ ___″ N / ___° ___′ ___″ W Total Acres:
Assessor's Parcel No.: n/a
Section: Various Twp.: ___ Range: ___ Base: ___
Within 2 Miles: State Hwy #: Multiple
Waterways: Multiple
Airports: Multiple
Railways:
Schools: Multiple

Document Type:

CEQA: ☒ NOP ☐ Early Cons ☐ Neg Dec ☐ Mit Neg Dec ☐ Draft EIR ☐ Supplement/Subsequent EIR (Prior SCH No.) ___ Other: ___

NEPA: ☐ NOI ☐ EA ☐ Draft EIS ☐ FONSI

Other: ☐ Joint Document ☐ Final Document ☐ Other: ___

Governor's Office of Planning & Research

AUG 17 2018

STATE CLEARINGHOUSE

Local Action Type:

☐ General Plan Update
☐ General Plan Amendment
☐ General Plan Element
☐ Community Plan
☐ Specific Plan
☐ Master Plan
☐ Planned Unit Development
☐ Site Plan
☐ Rezone
☐ Prezone
☐ Use Permit
☐ Land Division (Subdivision, etc.)
☐ Annexation
☐ Redevelopment
☐ Coastal Permit
☒ Other: FMP

Development Type:

☐ Residential: Units ___ Acres ___
☐ Office: Sq.ft. ___ Acres ___ Employees ___
☐ Commercial: Sq.ft. ___ Acres ___ Employees ___
☐ Industrial: Sq.ft. ___ Acres ___ Employees ___
☐ Educational: ___
☐ Recreational: ___
☐ Water Facilities: Type ___ MGD ___
☐ Transportation: Type ___
☐ Mining: Mineral ___
☐ Power: Type ___ MW ___
☐ Waste Treatment: Type ___ MGD ___
☐ Hazardous Waste: Type ___
☐ Other: ___

Project Issues Discussed in Document:

☒ Aesthetic/Visual
☒ Agricultural Land
☒ Air Quality
☒ Archeological/Historical
☒ Biological Resources
☒ Coastal Zone
☒ Drainage/Absorption
☐ Economic/Jobs
☐ Fiscal
☒ Flood Plain/Flooding
☒ Forest Land/Fire Hazard
☒ Geologic/Seismic
☒ Minerals
☒ Noise
☒ Population/Housing Balance
☒ Public Services/Facilities
☒ Recreation/Parks
☒ Schools/Universities
☒ Septic Systems
☒ Sewer Capacity
☒ Soil Erosion/Compaction/Grading
☒ Solid Waste
☒ Toxic/Hazardous
☒ Traffic/Circulation
☒ Vegetation
☒ Water Quality
☒ Water Supply/Groundwater
☒ Wetland/Riparian
☒ Growth Inducement
☒ Land Use
☒ Cumulative Effects
☐ Other: ___

Present Land Use/Zoning/General Plan Designation:

Commercial and recreational fishing in state waters, excluding marine protected areas that prohibit take

Project Description: *(please use a separate page if necessary)*

See attachment.

Note: The State Clearinghouse will assign identification numbers for all new projects. If a SCH number already exists for a project (e.g. Notice of Preparation or previous draft document) please fill in.

Revised 2010

Reviewing Agencies Checklist

Lead Agencies may recommend State Clearinghouse distribution by marking agencies below with and "**X**".
If you have already sent your document to the agency please denote that with an "**S**".

- X Air Resources Board
- X Boating & Waterways, Department of
- ___ California Emergency Management Agency
- ___ California Highway Patrol
- ___ Caltrans District # ___
- ___ Caltrans Division of Aeronautics
- ___ Caltrans Planning
- ___ Central Valley Flood Protection Board
- ___ Coachella Valley Mtns. Conservancy
- X Coastal Commission
- ___ Colorado River Board
- X Conservation, Department of
- ___ Corrections, Department of
- ___ Delta Protection Commission
- ___ Education, Department of
- ___ Energy Commission
- S Fish & Game Region # 7
- ___ Food & Agriculture, Department of
- ___ Forestry and Fire Protection, Department of
- ___ General Services, Department of
- ___ Health Services, Department of
- ___ Housing & Community Development
- ___ Native American Heritage Commission
- ___ Office of Historic Preservation
- ___ Office of Public School Construction
- X Parks & Recreation, Department of
- ___ Pesticide Regulation, Department of
- ___ Public Utilities Commission
- X Regional WQCB # 1,2,3
- X Resources Agency
- ___ Resources Recycling and Recovery, Department of
- X S.F. Bay Conservation & Development Comm.
- ___ San Gabriel & Lower L.A. Rivers & Mtns. Conservancy
- ___ San Joaquin River Conservancy
- ___ Santa Monica Mtns. Conservancy
- X State Lands Commission
- ___ SWRCB: Clean Water Grants
- ___ SWRCB: Water Quality
- ___ SWRCB: Water Rights
- ___ Tahoe Regional Planning Agency
- ___ Toxic Substances Control, Department of
- ___ Water Resources, Department of
- X Other: National Park Service
- X Other: United States Coast Guard

Local Public Review Period (to be filled in by lead agency)

Starting Date August 17, 2018 Ending Date September 21, 2018

Lead Agency (Complete if applicable):

Consulting Firm: ___ Applicant: ___
Address: ___ Address: ___
City/State/Zip: ___ City/State/Zip: ___
Contact: ___ Phone: ___
Phone: ___

Signature of Lead Agency Representative: Melissa A. Miller-Henson **Date:** 8/17/18

Authority cited: Section 21083, Public Resources Code. Reference: Section 21161, Public Resources Code.

Revised 2010

Project Description:

The proposed project is the adoption of a Fishery Management Plan (FMP) for Pacific Herring fishing under the State's jurisdiction. The project includes both commercial and recreational fishing as an element of the Department of Fish and Wildlife's (Department) Pacific Herring management program. Herring are primarily harvested commercially for their roe (eggs) during the months of January through March (spawning season) using small-mesh, set gill nets to take whole fish.

Minor fisheries are also conducted for roe on kelp, human consumption and bait purposes. Once the FMP is adopted, regulations implementing the FMP and the State's policies for managing the commercial and recreational take of Pacific Herring will be considered for inclusion in the California Code of Regulations (CCR). The proposed project includes recommendations for continuation, amendment, or change to an existing body of regulations (Sections 27.6,163, 163.5, and 164, Title 14, CCR). The recommendations are based on fishery modeling, biological assessments of existing stock conditions and comments received from the FMP Steering Committee, interested individuals, commercial fishermen, and from the Director's Herring Advisory Committee.

The Pacific Herring FMP would further refine and implement the long-term management objectives as well as meet requirements for fisheries management under the Marine Life Management Act. The FMP would serve as the framework to manage the commercial and recreational fishery for Pacific Herring in accordance with Fish and Game Code (§§ 8550-8559, 7078. Amendments to existing regulations, if adopted, will implement the FMP pursuant to Fish and Game Code sections 7072, 7075, and 7080-7088.

Project Location:

The project is located within state waters in coastal northern and central California, including San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor, encompassing the following counties: San Mateo, San Francisco, Alameda, Contra Costa, Marin, Humboldt, and Del Norte.

Notice of Preparation

To: State Clearinghouse, OPR
P.O. Box 3044
Sacramento, CA 95812-3044

From: California Dept. of Fish and Wildlife
Marine Region
5355 Skylane Blvd Suite B
Santa Rosa, CA 95403

Subject: Notice of Preparation of a Certified Regulatory Program Draft Environmental Document

The California Fish and Game Commission, with assistance from the California Department of Fish and Wildlife, will be the Lead Agency and will prepare a certified regulatory program environmental analysis for the project identified below. We need to know the views of your agency as to the scope and content of the environmental information which is germane to your agency's statutory responsibilities in connection with the proposed project. Your agency may need to use functional equivalent environmental analysis prepared by our agency when considering your permit or other approval for the project.

The project description, location, and the potential environmental effects are contained in the attached materials. A copy of the Initial Study (☒ is ☐ is not) attached.

Due to the time limits mandated by State law, your response must be sent at the earliest possible date but not later than 30 days after receipt of this notice.

Please send your response to Ryan Bartling at the address shown above. We will need the name for a contact person in your agency.

Project Title: Pacific Herring Fishery Management Plan and Regulatory Amendments

Project Applicant, if any: ____________________

Date 8/17/18

Signature Melissa A. Miller-Henson

Title Deputy Executive Director

Telephone 916-653-4899

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Marine Region
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

August 17, 2018

NOTICE OF PREPARATION OF AN ENVIRONMENTAL DOCUMENT AND PUBLIC SCOPING MEETING NOTICE FOR THE PACIFIC HERRING FISHERY MANAGEMENT PLAN AND REGULATORY AMENDMENTS PROJECT

The California Department of Fish and Wildlife (CDFW) is preparing a Fishery Management Plan (FMP) for Pacific Herring (*Clupea pallasii*). The California Fish and Game Commission (Commission), with assistance from CDFW, is providing this formal notice as the project lead agency pursuant to the California Environmental Quality Act (CEQA). CDFW, assisting the Commission under its certified regulatory program, has prepared the attached Initial Study (IS), detailed project description, and a preliminary analysis of the impacts identified in the IS. (See Cal. Code Regs., tit. 14, § 781.5.) The public comment period for this Notice of Preparation (NOP) is from August 17, 2018 to September 21, 2018. Comments may be provided by email to Ryan Bartling at Ryan.Bartling@wildlife.ca.gov or by letter to the following address:

Attn: Ryan Bartling
California Department of Fish and Wildlife
5355 Skylane Blvd, Suite B
Santa Rosa, CA 95403

Pacific Herring is a natural resource managed currently by CDFW under the Commission's annual rulemaking process. The existing herring fishery is closely regulated through a catch quota system, limited entry permits, seasons, gear restrictions, closed fishing areas, and landing and monitoring restrictions. The Pacific Herring FMP, if adopted by the Commission, would further refine and implement the long-term management objectives as well as meet requirements for fisheries management under the Marine Life Management Act. The FMP, if adopted, will serve as the framework to manage the commercial and recreational fishery for Pacific Herring in accordance with Fish and Game Code (FGC) §§ 8550-8559, 7078. Amendments to existing regulations, if adopted, will implement the FMP pursuant to Fish and Game Code sections 7072, 7075, and 7080-7088.

The project to be described is commercial and recreational fishing as an element of the Department's Pacific Herring management program. The locations of the project are San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor. Herring are primarily harvested for their roe (eggs) during the months of January through March (spawning season) using small mesh gill nets to take whole fish. Minor fisheries are also conducted for roe on kelp, human consumption and bait purposes.

A public hearing as part of the scoping effort will be held August 25, 2018 at the Bay Model Visitor's Center, 2100 Bridgeway, Sausalito, CA from 10:00am to 12:00pm. The meeting is being held to solicit comments on the environmental impacts of the proposed project and answer questions related to FMP development.

CEQA APPENDIX G:
ENVIRONMENTAL CHECKLIST FORM

1. **Project Title:** Pacific Herring Fishery Management Plan and Proposed Regulatory Amendments

2. **Lead Agency:**
   California Fish and Game Commission
   P.O. Box 944209
   Sacramento, CA 94244-2090

3. **Lead Agency Contact Persons:**
   Valerie Termini
   California Fish and Game Commission
   P.O. Box 944209
   Sacramento, CA 94244-2090

   Ryan Bartling
   California Department of Fish and Wildlife
   5355 Skylane Blvd, Suite B
   San Rosa, CA 95403

4. **Project Location:**
   The project is located within state waters in coastal northern and central California, including San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor, encompassing the following counties: San Mateo, San Francisco, Alameda, Contra Costa, Marin, Humboldt, and Del Norte (Figure 1).

5. **General Plan Designation:** NA

6. **Zoning:** NA

7. **Description of project:**
   The proposed project is the adoption of a Fishery Management Plan (FMP) for Pacific Herring fishing under the State's jurisdiction. The project includes both commercial and recreational fishing as an element of the Department of Fish and Wildlife's (Department) Pacific Herring management program. Herring are primarily harvested commercially for their roe (eggs) during the months of January through March (spawning season) using small-mesh, set gill nets to take whole fish.

   Minor fisheries are also conducted for roe on kelp, human consumption and bait purposes. Once the FMP is adopted, regulations implementing the FMP and the State's policies for managing the commercial and recreational take of Pacific Herring will be considered for inclusion in the California Code of Regulations (CCR). The proposed project includes recommendations for continuation, amendment, or change to an existing body of regulations (Sections 27.6,163, 163.5, and 164, Title 14, CCR). The recommendations are based on fishery modeling, biological assessments of existing stock conditions and comments received from the FMP Steering Committee, interested individuals, commercial fishermen, and from the Director's Herring Advisory Committee.

The Pacific Herring FMP would further refine and implement the long-term management objectives as well as meet requirements for fisheries management under the Marine Life Management Act. The FMP would serve as the framework to manage the commercial and recreational fishery for Pacific Herring in accordance with Fish and Game Code (§§ 8550-8559, 7078). Amendments to existing regulations, if adopted, will implement the FMP pursuant to Fish and Game Code sections 7072, 7075, and 7080-7088.

8. <u>Surrounding land uses and setting: Briefly describe the project's surroundings:</u>
The project occurs in the marine environment within state waters that are open for take of fish and marine invertebrate resources. The project area includes San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor (Figure 1).

San Francisco Bay is an estuary which is separated from the Pacific Ocean by an approximately one-mile wide natural opening called the Golden Gate. San Francisco Bay is situated on the central California coast and surrounded by several large cities including San Francisco, San Jose, and Oakland. The area ranges from highly urbanized cities to large areas of open parkland. The bay is characterized by broad shallows carved by narrow channels whose depths are maintained by swiftly moving currents. The Bay encompasses an area of approximately 550 square miles with an average depth of 20 feet, the maximum depth is 360 feet near the Golden Gate Bridge.

Tomales Bay is located approximately 40 miles north of San Francisco. The bay occupies the northern end of the San Andreas Rift between the Point Reyes Peninsula and the rest of the coast. The west side of the Bay is bordered by Point Reyes National Seashore and the east shore is a mix of agricultural (grazing and dairy) and open space. The bay encompasses an area of 11 square miles, is 13 miles long and slightly over 1 mile wide at its widest with an average depth of less than 20 feet. Tomales Bay has several aquaculture lease operations, small coastal villages and is used for many watersport activities such as kayaking, fishing and sailing.

Humboldt Bay is located approximately 200 miles north of San Francisco. The bay is about 25 square miles in size and is 14 miles long and 4.5 miles wide at its widest point. The bay consists of three regions: North (Arcata) Bay, Entrance Bay, and South Bay. Entrance Bay has one deep connecting channel that leads to the ocean through two concrete and rock jetties. The bay is separated from the ocean by two long sand spits. Tidal channels average 25 feet in depth near the bay mouth and decrease in depth in the bay's upper reaches. The largest coastal communities surrounding the shores of the North and Entrance Bays are Arcata and Eureka, respectively, with Eureka being the largest. Land and water bottom uses include aquaculture, timber harvesting and tourism.

Crescent City Harbor is approximately 20 miles south of the Oregon - California Border and approximately 350 miles north of San Francisco. The area is primarily rocky open coast with a small harbor protected by a southwest facing rock jetty. The area is home to commercial fishing and the small community of Crescent City.

9. <u>Other public agencies whose approval is required (e.g., permits, financing approval, or participation agreement):</u> NA

10. **<u>Have California Native American tribes traditionally and culturally affiliated with the project area requested consultation pursuant to Public Resources Code Section 21080.3.1? If so, has consultation begun?</u>** See "Discussion of Checklist," section XVII.

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:
The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

☐ Aesthetics	☐ Agriculture and Forestry Resources	☐ Air Quality
☒ Biological Resources	☐ Cultural Resources	☐ Geology /Soils
☐ Greenhouse Gas Emissions	☐ Hazards & Hazardous Materials	☐ Hydrology / Water Quality
☐ Land Use / Planning	☐ Mineral Resources	☐ Noise
☐ Population / Housing	☐ Public Services	☐ Recreation
☐ Transportation/Traffic	☐ Tribal Cultural Resources	☐ Utilities/Service Systems

☐ Mandatory Findings of Significance

DETERMINATION: (To be completed by the Lead Agency)
On the basis of this initial evaluation:

☐ I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

☐ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.

☒ I find that the proposed project MAY have a significant effect or potentially significant effect on the environment, and a functional equivalent environmental analysis should be prepared under the Fish and Game Commission’s certified regulatory program. (Cal. Code Regs., tit. 14, § 781.5.)

☐ I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the proposed project, nothing further is required.

____ ______________________________
Valerie Termini, Executive Director — Date
California Fish and Game Commission

EVALUATION OF ENVIRONMENTAL IMPACTS

1) A brief explanation is required for all answers except "No Impact" answers that are adequately supported by the information sources a lead agency cites in the parentheses following each question. A "No Impact" answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (e.g., the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors as well as general standards (e.g., the project will not expose sensitive receptors to pollutants, based on a project-specific screening analysis).

2) All answers must take account of the whole action involved, including off-site as well as on-site, cumulative as well as project-level, indirect as well as direct, and construction as well as operational impacts.

3) Once the lead agency has determined that a particular physical impact may occur, then the checklist answers must indicate whether the impact is potentially significant, less than significant with mitigation, or less than significant. "Potentially Significant Impact" is appropriate if there is substantial evidence that an effect may be significant. If there are one or more "Potentially Significant Impact" entries when the determination is made, an EIR is required.

4) "Negative Declaration: Less Than Significant With Mitigation Incorporated" applies where the incorporation of mitigation measures has reduced an effect from "Potentially Significant Impact" to a "Less Than Significant Impact." The lead agency must describe the mitigation measures, and briefly explain how they reduce the effect to a less than significant level (mitigation measures from "Earlier Analyses," as described in (5) below, may be cross-referenced).

5) Earlier analyses may be used where, pursuant to the tiering, program EIR, or other CEQA process, an effect has been adequately analyzed in an earlier EIR or negative declaration. Section 15063(c)(3)(D). In this case, a brief discussion should identify the following:
   a) Earlier Analysis Used. Identify and state where they are available for review.
   b) Impacts Adequately Addressed. Identify which effects from the above checklist were within the scope of and adequately analyzed in an earlier document pursuant to applicable legal standards, and state whether such effects were addressed by mitigation measures based on the earlier analysis.
   c) Mitigation Measures. For effects that are "Less than Significant with Mitigation Measures Incorporated," describe the mitigation measures which were incorporated or refined from the earlier document and the extent to which they address site-specific conditions for the project.

6) Lead agencies are encouraged to incorporate into the checklist references to information sources for potential impacts (e.g., general plans, zoning ordinances). Reference to a previously prepared or outside document should, where appropriate, include a reference to the page or pages where the statement is substantiated.

7) Supporting Information Sources: A source list should be attached, and other sources used or individuals contacted should be cited in the discussion.

8) This is only a suggested form, and lead agencies are free to use different formats; however, lead agencies should normally address the questions from this checklist that are relevant to a project's environmental effects in whatever format is selected.

9) The explanation of each issue should identify:
   a) the significance criteria or threshold, if any, used to evaluate each question; and
   b) the mitigation measure identified, if any, to reduce the impact to less than significance

ISSUES:

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
I. AESTHETICS. Would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☒	☐
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☒
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☐	☒
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☒
II. AGRICULTURE AND FORESTRY RESOURCES. In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board. Would the project:				

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))?	☐	☐	☐	☒
d) Result in the loss of forest land or conversion of forest land to non-forest use?	☐	☐	☐	☒
e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	☐	☐	☐	☒
III. AIR QUALITY. Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☒
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☐	☐	☒
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☐	☐	☒	☐
d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☒
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☒
IV. BIOLOGICAL RESOURCES: Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or	☐	☐	☒	☐

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?				
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?	☐	☐	☒	☐
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☐	☒
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☒
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒
(g) Impact a native fish or wildlife species through authorized take in a commercial or recreational fishing or hunting program?	☒	☐	☐	☐

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
V. CULTURAL RESOURCES. Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in § 15064.5?	☐	☐	☐	☒
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to § 15064.5?	☐	☐	☐	☒
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☐	☒
d) Disturb any human remains, including those interred outside of dedicated cemeteries?	☐	☐	☐	☒
VI. GEOLOGY AND SOILS. Would the project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
ii) Strong seismic ground shaking?	☐	☐	☐	☒
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☒
iv) Landslides?	☐	☐	☐	☒
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☐	☒
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☒
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?	☐	☐	☐	☒
VII. GREENHOUSE GAS EMISSIONS. Would the project:				
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?	☐	☐	☐	☒
b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?	☐	☐	☐	☒
VIII. HAZARDS AND HAZARDOUS MATERIALS. Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☐	☒
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☐	☒
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☒
IX. HYDROLOGY AND WATER QUALITY. Would the project:				
a) Violate any water quality standards or waste discharge requirements?	☐	☐	☐	☒
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☐	☒
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☐	☐	☐	☒
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☐	☒
f) Otherwise substantially degrade water quality?	☐	☐	☐	☒
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☐	☐	☐	☒
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☐	☒
j) Inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☒
X. LAND USE AND PLANNING. Would the project:				
a) Physically divide an established community?	☐	☐	☐	☒
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☒
XI. MINERAL RESOURCES. Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☒
XII. NOISE -- Would the project result in:				
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☒
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☐	☒
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☒
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☒
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
<u>XIII. POPULATION AND HOUSING.</u> Would the project:				
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☒
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
<u>XIV. PUBLIC SERVICES.</u>				
a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				
Fire protection?	☐	☐	☐	☒
Police protection?	☐	☐	☐	☒
Schools?	☐	☐	☐	☒
Parks?	☐	☐	☐	☒
Other public facilities?	☐	☐	☐	☒
<u>XV. RECREATION.</u>				
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☐	☐	☐	☒
<u>XVI. TRANSPORTATION/TRAFFIC.</u>				
Would the project:				
a) Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?	☐	☐	☐	☒
b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?	☐	☐	☐	☒
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☒
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☒
e) Result in inadequate emergency access?	☐	☐	☐	☒
f) Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
XVII. TRIBAL CULTURAL RESOURCES a) Would the project cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code section 21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:				
i) Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code section 5020.1(k), or	☐	☐	☒	☐
ii) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code Section 5024.1. In applying the criteria set forth in subdivision (c) of Public Resource Code Section 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe.	☐	☐	☒	☐
XVIII. UTILITIES AND SERVICE SYSTEMS. Would the project:				
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☒
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☒
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☒

	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant Impact	No Impact
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☒
g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒
XIX. MANDATORY FINDINGS OF SIGNIFICANCE				
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☒	☐
b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☐	☒	☐
c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☒

Note: Authority cited: Sections 21083 and 21083.05, 21083.09 Public Resources Code. Reference: Section 65088.4, Gov. Code; Sections 21073, 21074 21080(c), 21080.1, 21080.3, 21083, 21083.05, 21083.3, 21080.3.1, 21080.3.2,21082.3, 21084.2, 21084.3, 21093, 21094, 21095, and 21151, Public Resources Code; *Sundstrom v. County of Mendocino,*(1988) 202 Cal.App.3d 296; *Leonoff v. Monterey Board of Supervisors,* (1990) 222 Cal.App.3d 1337; *Eureka Citizens for Responsible Govt. v. City of Eureka* (2007) 147 Cal.App.4th 357; *Protect the Historic Amador Waterways v. Amador Water Agency* (2004) 116 Cal.App.4th at 1109; *San Franciscans Upholding the Downtown Plan v. City and County of San Francisco* (2002) 102 Cal.App.4th 656.

DISCUSSION OF CHECKLIST

I. Aesthetics. Would the project:

a) Have a substantial adverse effect on a scenic vista?

Less Than Significant. The project area may be visible from scenic vistas, depending on the fishing location and fish behavior, in a way consistent with current, baseline conditions within the project area. During the open season, fishing activities may concentrate along shoreline areas, near roads and public piers. The scenic quality of herring fisheries will be viewed as aesthetically pleasing by some and not by others. All of these activities are seasonal and do not leave behind permanent structures. In addition, implementation of the FMP and regulatory amendments would not substantially increase or decrease the level of fishing activity within the project area such that views from a scenic vista would be degraded. Therefore, the FMP and regulatory amendments would not have a substantial adverse effect on scenic vistas.

b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a scenic highway?

No Impact. The project area is within marine and estuarine environments, there are no trees or historic buildings within a scenic highway located within the project area. The FMP and regulatory amendments would not substantially change the type or level of fishing activities such that views within the project area would change substantially. Therefore, no impact would occur.

c) Substantially degrade the existing visual character or quality of the site and its surroundings?

No Impact. The herring fishery is not currently known to substantially degrade the existing scenery of the coastline, and the FMP and regulatory amendments would not result in substantial changes in the type or level of fishing activities that would degrade the existing visual character or quality of the project site and its surroundings. Therefore, no impact would occur.

d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

No Impact. The commercial herring fishery occurs from vessels that must adhere to regulations set forth by the United States Coast Guard under Rule 26. Fishing vessels also must adhere to California Code of Regulations Title 14 § 163 (f)(2)(F) which describe net marking requirements. Implementation of the FMP and regulatory amendments would not alter these requirements, and no increase or decrease in the amount of light or glare from fishing operations would occur. The project would not create or produce new light sources or glare. Therefore, no impact would occur.

II. Agriculture. Would the project:

a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program (FMMP) of the California Resources Agency, to non-agricultural use?
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?

No Impact. The project is within marine and estuarine environments, it does not contain any Prime Farmland, Unique Farmland, or Farmland of Statewide Importance, as mapped by the FMMP. The herring fishery has no effect on terrestrial agriculture, and the project would not cause changes that would result in direct or indirect conversion of these types of farmland. In addition, there is no potential for conflict with zoning for agricultural use or a Williamson Act contract due to the project's location. Therefore, no impact would occur.

c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code [PRC] section 12220(g)), timberland (as defined by PRC section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))?
d) Result in the loss of forest land or conversion of forest land to non-forest use?

No Impact. The project area is within marine and estuarine environments and does not contain any forestland as defined by PRC, nor does it contain timberland, or zoned Timberland Production as defined by the Government Code. The herring fishery has no effect on forestland or other related resources, and the project would not cause changes that would result in direct or indirect conversion of or conflict with zoning related to forestland types of land uses. Therefore, there is no impact.

e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use or conversion of forest land to non-forest use?

No Impact. The herring FMP and regulatory amendments would only involve changes to the existing management of the herring fishery, which is located in the marine and estuarine environment. No change to the land uses in the surrounding terrestrial areas is anticipated; therefore, the FMP and regulatory amendments would not result in any changes or conversion to either Important Farmland or forest land uses to other land uses. Therefore, no impact would occur.

III. Air Quality. Would the project:

a) Conflict with or obstruct implementation of the applicable air quality plan?

No Impact. The proposed project occurs includes bays and coastal areas that are encompassed by San Francisco, San Mateo, Alameda, Contra Costa, Marin, Humboldt, and Del Norte Counties, which are under the San Francisco Bay Area and North Coast air basins.

The purpose of any air quality plan is to reduce criteria and toxic air pollutants in a particular region. These plans can be established by jurisdictional agencies such as air districts or through a general plan document. Typical air quality plans in given air districts address the feasibility and actions that air districts should take to meet or maintain state and federal clean air standards. As shown in Table 1, air districts within the project area are at non-attainment status in the southern portion and at unclassified/attainment in the northern portion with respect to state and national standards, except for the PM_{10}.

Table 1. National and State Air Quality Attainment Statuses at Affected Counties

County	Ozone[a]	PM_{10}	$PM_{2.5}$[b]
National Standard			
Del Norte	Unclassified/Attainment	Unclassified/Attainment	Unclassified/Attainment
Humboldt	Unclassified/Attainment	Unclassified/Attainment	Unclassified/Attainment
Marin	Nonattainment	Unclassified/Attainment	Nonattainment
San Mateo	Nonattainment	Unclassified/Attainment	Nonattainment
San Francisco	Nonattainment	Unclassified/Attainment	Nonattainment
Alameda	Nonattainment	Unclassified/Attainment	Nonattainment
Contra Costa	Nonattainment	Unclassified/Attainment	Nonattainment
State Standard			
Del Norte	Attainment	Attainment	Attainment

Humboldt	Attainment	Attainment	Nonattainment
Marin	Nonattainment	Nonattainment	Nonattainment
San Mateo	Nonattainment	Nonattainment	Nonattainment
San Francisco	Nonattainment	Nonattainment	Nonattainment
Alameda	Nonattainment	Nonattainment	Nonattainment
Contra Costa	Nonattainment	Nonattainment	Nonattainment

a. Reflects the national 8-hour standard. The 1-hour standard was revoked on June 15, 2005.
b. Reflects the latest 2012 $PM_{2.5}$ standard.

Source: CARB 2017; USEPA 2018

Air quality plans within general plan documents are usually written as goals, actions, and policies that prohibit or limit land use development actions that would worsen air quality. Any project or plan that would result in short-term or long-term increases in air pollutants would be at risk of conflicting with or obstructing applicable air quality plans. Whether or not an actual conflict would occur depends on the specific limitations presented in the air quality plans and would vary by region.

The proposed FMP and regulatory amendments would result in establishing an updated management framework for the recreational and commercial Pacific Herring fishery and would not directly conflict with or obstruct with the implementation of any applicable air quality plans. Therefore, no impact would occur.

b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?

No Impact. The proposed project would not result in increased emissions of air pollutants or contaminants over existing conditions. Movement, concentration, or location of fishing activities would remain similar to baseline conditions under the FMP; therefore, the FMP is not anticipated to impact air quality for air districts within the project area (see district thresholds of significance listed in Table 2). The proposed project would not violate any air quality standard or contribute substantially to an existing or projected air quality violation. Therefore, no impact would occur.

Table 2. Threshold of Significance for Each Affected Air District for Operational Impacts Only

Air District	NOx	ROG	PM_{10}	$PM_{2.5}$
North Coast Unified AQMD[a]	50 lb/day	50 lb/day[b]	80 lb/day	50 lb/day
Bay Area AQMD	54 lb/day	54 lb/day	82 lb/day (exhaust)	54 lb/day (exhaust)

a. North Coast Unified AQMD has not adopted CEQA thresholds of significance. These thresholds reflect published screening level thresholds for air quality impact analyses for new sources.
b. Threshold for reactive organic compounds.

Source: North Coast Unified AQMD 2015, Bay Area AQMD 2017

c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?

Less Than Significant. Air quality is affected by emissions generated from the operation of gas and diesel engines in commercial fishing vessels, and from the operation of gas and diesel engines in support vehicles. Pollutant emissions released when vessels are underway are influenced by a variety of factors including power source, engine size, fuel used, operating speed, and load. The implementation of the FMP and proposed regulatory amendments would not anticipate an increase in vessel capacity and would establish a long-term capacity limit on the number of vessels in the fleet. No long-term adverse impacts to air quality are anticipated since no increased vessel activity is expected as a result of adopting the proposed FMP or implementing regulations. The project would not result in a cumulative net increase of any criteria pollutant for which the plan region is in non-attainment under an applicable federal or state ambient air quality standard.

d) Expose sensitive receptors to substantial pollutant concentrations?

No Impact. Sensitive receptors are typically defined as schools, hospitals, residential care facilities, daycare facilities, or other facilities that may house individuals with health conditions that would be adversely impacted by changes in air quality. The proposed project is the preparation and implementation of the Pacific Herring FMP and proposed regulatory amendments. The project does not propose uses or activities that would result in exposure of these identified sensitive receptors to significant pollutants. Therefore, no impact would occur.

e) Create objectionable odors affecting a substantial number of people?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The project does not proposed any construction or operational impacts that would significantly create objectionable odors affecting a substantial number. Therefore, no impact would occur.

IV. Biological Resources. Would the project:

a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or the U.S. Fish and Wildlife Service?
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations or by the California Department of Fish and Wildlife or the U.S. Fish and Wildlife Service?

Less Than Significant. There are a number of special status or otherwise protected species that are known to occur or may occur in the project area. The potential exists for any fish or invertebrate in the area of fishing to be taken; however, the species most likely to be taken are relatively small in size and vulnerable to the mesh size used in the commercial fishery. The method of take employed by the commercial Pacific Herring fishery is limited to set gill nets of a mesh size that selects adult herring. Therefore, the existing selective fishing practices ensure a low risk of impact to non-target organisms and surrounding habitats. A midwater trawl and research gill nets with mesh sizes that overlap the commercially legal mesh size are used to independently sample the herring population. There is potential to incidentally capture special status or otherwise protected species during research activities; however, the FMP does not anticipate an increase in research activity above the current, baseline conditions within the project area. The FMP will maintain the existing fishing season, commercial gear restrictions, and closure areas, which limits incidental take of non-target species by the commercial fishery. Cast net fishing in the recreational fishery targets spawning herring in shallow habitat at a time of year when protected species are not likely to occur. The FMP focuses on the commercial and recreational herring fisheries, and continues to implement the long-term management objectives that have been developed by the herring management project. Preventing or limiting bycatch of all types has been a long standing objective of CDFW’s management program for herring.

The development of the Pacific Herring FMP is also based on the principles adopted as part of the MLMA. To this end, the project minimizes potential effects to sensitive natural communities and habitats identified through state regulations, most of which are administered by CDFW. Although fishing practices may have some minor effects on the marine environment, the FMP and regulatory amendments would continue to prevent negative effects to the marine environment and ecosystem through its management and proposed regulatory changes. Therefore, this impact would be less than significant.

c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The project would not result in removal, fill, hydrologic interruption, or other activities that would result in a direct substantial adverse effect on federally protected wetlands. Therefore, no impact would occur.

d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. As discussed under questions IV (a-c), substantial impacts to habitats and substrates would not occur as a result of the FMP and regulatory amendments. As such, no substantial interference with movement or effect to native wildlife nursery sites would occur. Therefore, no impact would occur.

e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?

f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?

No Impact. There are no Habitat Conservation Plans or Natural Community Conservation Plans within the project area. The guiding regulation regarding conservation in the project area is the MLMA. The Pacific Herring FMP and proposed regulatory changes have been developed in conjunction with the goals of the MLMA and do not conflict with its provisions. Specifically, the MLMA calls for “conservation, sustainable use, and restoration of California’s marine living resources.” This includes the conservation of healthy and diverse marine ecosystems and marine living resource,” including the development of FMPs. Because the FMP and regulatory amendments have been developed as a result of and in accordance with the MLMA, there would be no conflict with these or other local policies; thus, there is no impact.

(g) Impact a native fish or wildlife species through authorized take in a commercial or recreational fishing or hunting program?

Potentially Significant Impact. The Commission recognizes that any FMP, under appropriate circumstances, would allow for take of a fish species (Pacific Herring in this proposed project). Any take through fishing effort increases mortality rates to the spawning stock beyond what would naturally occur in the absence of fishing. Out of an abundance of caution, the Commission plans to further evaluate whether the proposed FMP may have significant effects on the Pacific Herring population. However, the goal of the FMP is to improve the long-term sustainability of the fishery in accordance with the MLMA, and ensure appropriate management tools are used to protect the resource. The proposed FMP provides management guidance and thresholds that are consistent with existing conditions in the project area and prevent over exploitation, helping to ensure a sustainable fishery based on accepted fishery management principles. The Commission anticipates the potentially significant beneficial impacts to the spawning stock due to the inclusion of a peer reviewed Harvest Control Rule in the FMP, specifically for the only active herring fishery in California (San Francisco Bay).

V. Cultural Resources. Would the project:

a) Cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5?

No Impact. The proposed project would not directly or indirectly disturb any historical resources or alter activity around any known historical resources beyond baseline conditions. The herring fishery occurs in estuaries and harbors where natural conditions are typically mud bottom subjected to high levels of natural disturbance due to tides and currents. Therefore, there would be no impact.

b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5?

No Impact. CA State law (PRC §§ 6313, 6314) prohibits all unauthorized salvage and removal of artifacts from submerged archaeological sites in state waters, which are under the jurisdiction of SLC. The proposed project would not modify this existing state law. Furthermore, the proposed project would not result in construction or significant disturbance to the bottoms of bays or estuaries. Therefore, the proposed project would have no to impact submerged archaeological resources.

c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

No Impact. The proposed project would not result in an increase in activities that would directly or indirectly destroy paleontological or geologic features. The proposed project will have minimal effect on the sea floor, which is where paleontological and geological features have the potential to occur. Therefore, no impact would occur.

d) Disturb any human remains, including those interred outside of formal cemeteries?

No Impact. The proposed project would not result in excavation or other activities onshore or offshore that have the potential to directly or indirectly disturb any known cemeteries or burial grounds. Therefore, no impact would occur.

VI. Geology and Soils. Would the project:

a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to California Geological Survey Special Publication 42.

No Impact. Portions of the project area are within the Alquist-Priolo Earthquake Fault Zones and several faults are located within the area. However, the project area is within a marine/estuarine environment, and implementation of the FMP and regulatory amendments would not include construction of any structures that would directly expose people or structures to rupture of an earthquake fault. Therefore, no impact would occur.

ii) Strong seismic ground shaking?

No Impact. The FMP and regulatory amendments pertain to the marine/estuarine environment and would not directly expose or increase existing exposure of people or structures to seismic ground shaking that could occur on land. Therefore, no impact would occur.

iii) Seismic-related ground failure, including liquefaction?

No Impact. The FMP and regulatory amendments pertain to the marine/estuarine environment and would not directly expose people or structures to seismic-related ground failure or liquefaction that could occur on land nor increase existing exposure. This impact would be less than significant.

iv) Landslides?

No Impact. The FMP and regulatory amendments pertain to the marine/estuarine environment and would not directly expose people or structures to landslides that could occur on land or increase existing exposure. This impact would be less than significant.

b) Result in substantial soil erosion or the loss of topsoil?

No Impact. The project area is within a marine/estuarine environment, and soil erosion and loss of topsoil are land-based occurrences. Therefore, the FMP and regulatory amendments would have no impact on soil erosion or loss of topsoil.

c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?

No Impact. The project area is within a marine/estuarine environment, and unstable soils is a land-based occurrence. Therefore, the FMP and regulatory amendments would have no impact on unstable soils.

d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

No Impact. The project does not involve the construction of buildings or structures that would create substantial risks to life or property. Therefore, the FMP and regulatory amendments would have no impact on expansive soils.

e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

No Impact. The project does not involve the construction of buildings or structures, nor propose the use of septic tanks as part of the FMP or regulatory amendments. Therefore, the FMP and regulatory amendments would have no impact on soils incapable of supporting septic tanks.

VII. Greenhouse Gas Emissions. Would the project:

a) Generate greenhouse gas (GHG) emissions, either directly or indirectly, that may have a significant impact on the environment?

No Impact. The implementation of the FMP and proposed regulatory amendments would not result in an overall increase of GHG emissions over existing conditions. Commercial and recreational fishing activity for Pacific Herring is seasonal and spatially distributed primarily in San Francisco Bay. Thus, it would not substantially affect associated fuel combustion above existing conditions. Therefore, no impact is anticipated.

b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The FMP would not conflict with any adopted plans, policies, or regulations for the purpose of reducing GHG emissions. Therefore, no impact would occur.

VIII. Hazards and Hazardous Materials. Would the project:

a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. Commercial and recreational fishing for herring does not generate any hazardous wastes that would create a significant hazard to the public or the environment. Therefore, no impact would occur.

b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and/or accident conditions involving the release of hazardous materials into the environment?

No Impact. The proposed project involves the adoption of Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. Commercial and recreational fishing for herring does not involve the use of hazardous materials. As such, no impact is anticipated for accidents related to the release hazardous materials into the environment.

c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. Commercial and recreational fishing for herring does not involve the use of hazardous materials. Therefore, no impact is anticipated relating to the emission or handling of hazardous materials, substances, or waste within one-quarter mile of any existing or proposed schools within the project area.

d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?

No Impact. Based on a regulatory database search, listed sites currently undergoing cleanup within the project study area are shown in Appendix B. None of the sites listed would be impacted by fishing activities from the herring fishery. The proposed project would not interfere with cleanup efforts, nor would it exacerbate hazardous conditions at the sites. Therefore, no impact would occur.

Source: California Department of Toxic Substances 2018
https://www.dtsc.ca.gov/SiteCleanup/Cortese_List.cfm

e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?

No Impact. There are airports within the vicinity of the project area. However, commercial and recreational herring fishing does not currently interfere with airport operations or air traffic that would result in the exposure of people to a safety hazard. Therefore, no impact would occur.

f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The proposed project would not interfere with airport operations or result in any changes to the air traffic patterns that would expose people to a safety hazard. Therefore, no impact would occur.

g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The FMP and regulatory amendments would not substantially change the fishing that is currently occurring within the project area. As such, the proposed project would not modify or interfere with any existing emergency response plan or emergency evacuation plan. Therefore, this impact would no impact.

h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?

No Impact. The project area is within the marine and estuarine environment and is not subject to wildfires. Therefore, no impact would occur.

IX. Hydrology and Water Quality. Would the project:

a) Violate any water quality standards or waste discharge requirements?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. There is no known contribution to the degradation of water quality nor is there known discharge of pollutants to the environment associated with current commercial and recreational fishing operations for herring. Therefore, no impact would occur.

b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The project occurs within the marine and estuarine environment and would not affect groundwater supplies or recharge. Furthermore, no facilities constructed with impervious surfaces that could affect groundwater are proposed as part of this project. Therefore, no impact would occur.

c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial on- or offsite erosion or siltation?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The project occurs within the marine and estuarine environment. No changes to land use are proposed as part of this project that would modify, either directly or indirectly, existing drainage patterns of any built structures, facilities, or hydrologic features that may exist in the project area in a manner which would result in substantial on- or offsite erosion or siltation. Therefore, no impact would occur.

d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in on- or offsite flooding?

No Impact. As discussed under question IX (c), the project occurs within the marine and estuarine environment and no changes to land use are proposed as part of this project that would affect structures, alter existing drainage patterns or other hydrologic features that could affect existing patterns of surface runoff or result in on- or off-site flooding from surface runoff. Therefore, no impact would occur.

e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?

No Impact. As discussed under questions IX (c) and (d), the project is within the marine and estuarine environment and no land use changes are proposed; as such, there would be no contribution to runoff water that would exceed the capacity of existing or planned stormwater drainage systems. In addition, the project would not result in changes to facilities, impervious surfaces, or other structures or stormwater drainage systems such that runoff volumes, flows, or quality of polluted runoff into stormwater drainage systems would be affected. Therefore, no impact would occur.

f) Otherwise substantially degrade water quality?

No Impact. As discussed under questions IX (a) and (c-d), the project does not propose land use changes nor would it create or contribute to discharge of pollutants into the environment that substantially degrade water quality. Therefore, no impact would occur.

g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?

No Impact. No housing is proposed as part of the project. Therefore, would be no impact to housing within a Flood Hazard Boundary or other flood hazard delineation map.

h) Place within a 100-year flood hazard area structures that would impede or redirect flood flows?

No Impact. No structures are proposed as part of the project. Therefore, there would be no impact to the 100-year flood hazard area or flood flows.

i) Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam?

No Impact. The proposed project is located within the marine and estuarine environment. There would be no effect related to or from flooding as a result of a levee or dam, as those types of events do not occur in the project area. Therefore, no impact would occur.

j) Inundation by seiche, tsunami, or mudflow?

No Impact. Seiche and mudflow are hazards generated primarily in terrestrial environments that could affect structures and people on land nearby to inland bodies of water and other inland hydrologic features. Although rare, the potential exists for tsunamis to occur in the project area. However, the proposed project would not increase the risk or vulnerability to hazards from inundation by seiche, tsunami, or mudflow beyond baseline conditions. Therefore, no impact would occur.

X. Land Use and Planning. Would the project:

a) Physically divide an established community?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. There are coastal communities adjacent to the project area; however, no communities would be divided, either directly or indirectly, from implementation of the FMP and regulatory amendments. Therefore, no impact would occur.

b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to a general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?

No Impact. The FMP and regulatory amendments would not conflict with any existing land use plan, policy, or regulation because these regulatory changes are focused on management of the commercial and recreational fishery which the Department has authority. Therefore, no impact would occur.

c) Conflict with any applicable habitat conservation plan or natural community conservation plan?

No Impact. The project area is not subject to a habitat conservation plan or natural community conservation plan. The proposed project involves the preparation of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. Therefore, no impact would occur.

XI. Mineral Resources. Would the project:

a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?

No Impact. Since no oil and gas extraction sites are located within the project area, implementation of the FMP and regulatory amendments would not affect the production or extraction of those resources. Thus, there would be no loss of any known mineral resources, or preclusion of future access to any mineral resources. Therefore, no impact would occur.

b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?

No Impact. Since no oil and gas extraction sites are located within the project area, the FMP and regulatory amendments would not affect the production or extraction of those resources. Thus, there would be no loss of or preclusion of future access to any mineral resources. Therefore, no impact would occur.

XII. Noise. Would the project:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The project would not result in any construction activity that would generate noise disturbances nor would it increase noise levels compared to baseline conditions. Therefore, no impact would occur.

b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?

No Impact. As discussed in question XII (a), the adoption project would not result in any construction or other activities that would generate groundborne vibration or groundborne noise levels. Therefore, no impact would occur.

c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. The project would not result in any permanent, fixed noise sources nor would it result in a substantial increase in ambient noise levels in the project vicinity above baseline conditions. Therefore, no impact would occur.

d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?

No Impact. The proposed project involves the adoption of a Pacific herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. No construction is proposed a part of the project that would result in temporary or periodic noise disturbances. Therefore, no impact would occur.

e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

No Impact. There are three public airports (San Francisco Airport, Oakland Airport, California Redwood Coast-Humboldt County Airport) located within a 2-mile radius of the project site. However, the proposed project involves the preparation of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. There would be no substantial effect on the existing noise conditions from implementation of the proposed project. In addition, the project would not locate sensitive receptors near the vicinity of a public or public use airport. Therefore, no impact would occur.

f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

No Impact. Similar to question XII (e), there would be no substantial effect on the existing noise conditions from implementation of the proposed project and no sensitive receptors would be located near the vicinity of a private airstrip. Therefore, no impact would occur.

XIII. Population and Housing. Would the project:

a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?

No Impact. The FMP and regulatory amendments would not include construction of new housing or commercial businesses. Therefore, no direct population growth would result from implementation of the FMP or regulatory amendments. In addition, the proposed changes would not require or indirectly cause any new construction or any infrastructure modification, and no additional temporary or permanent staff would be needed for operations and maintenance of the fishery. Therefore, no impact would occur.

b) Displace substantial numbers of existing homes, necessitating the construction of replacement housing elsewhere?

No Impact. The FMP and regulatory amendments would not remove any homes or require construction of replacement housing. Therefore, no impact would occur.

c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?

No Impact. The FMP and regulatory amendments would not displace any people or require construction of replacement housing. Therefore, no impact would occur.

XIV. Population and Housing. Would the project:

a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

Fire protection?

No Impact. No construction of any new government facilities or the alteration of any existing government facilities that would increase the demand for fire protection services is proposed as part of the project. In addition, the project area is within the marine environment and the potential for fires would be limited to those on board of fishing vessels. The FMP and regulatory amendment would not substantially increase the amount of vessels in the project area or the demand for fire services. Therefore, no impact would occur.

Police protection?

No Impact. The FMP and regulatory amendments would not involve the construction of any new government facilities or the alteration of any existing government facilities that would increase the demand for police protection services. In addition, the FMP and regulatory amendment would not substantially increase the amount of vessels in the project area or the demand for police or other law enforcement services. Therefore, no impact would occur.

Schools?

No Impact. The FMP and regulatory amendments would not involve the construction or alternation facilities that would increase the demand for schools. Therefore, no impact would occur.

Parks?

No Impact. The FMP and regulatory amendments would not involve the construction or alteration of any facilities that would increase the demand for parks. Therefore, no impact would occur.

Other public facilities?

No Impact. The FMP and regulatory amendments would not involve the construction or alteration of any facilities that would increase the demand for other public facilities. Therefore, no impact would occur.

XV. Recreation. Would the project:

a) Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?
b) Include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?

No Impact. The proposed project would not result in increased use of recreational facilities in neighborhood or regional parks above existing conditions. As a result no new construction or expansion would be required. Therefore, no impact would occur.

XVI. Transportation/Traffic. Would the project:

a) Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?

No impact. The proposed project would not conflict with any plans or policies related to circulation. The FMP and regulatory amendments would not conflict with the performance of existing circulation systems for traffic. Therefore, no impact would occur.

b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?

No Impact. The proposed project is located within the marine environment and is not subject to any congestion management program for roads or highways. Therefore, no impact would occur.

c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?

No Impact. The proposed project is within the marine environment and implementation of the project would not affect any air traffic patterns. Therefore, no impact would occur.

d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

No Impact. No new facilities would be constructed under the FMP or regulatory amendments, and implementation of these changes would not involve any design feature related to any transportation of traffic-related infrastructure. Therefore, no impact would occur.

e) Result in inadequate emergency access?

No Impact. The proposed project would not change emergency access within the project area. Therefore, no impact would occur.

f) Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?

No Impact. The proposed project is located within the marine environment. Implementation of the FMP and regulatory amendments would not affect adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities. Therefore, no impact would occur.

XVII. Tribal Cultural Resources. Would the project:

a) Cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code section 21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:

   i) Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code section 5020.1(k), or
   ii) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code Section 5024.1. In applying the criteria set forth in subdivision (c) of Public Resource Code Section 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?

Less Than Significant. Both the Commission and CDFW are committed to open communication with Tribes under their respective consultation policies (CDFW's Tribal Communication and Consultation Policy, which is available through the CDFW's Tribal Affairs webpage at https://www.wildlife.ca.gov/General-Counsel/Tribal-Affairs; Commission's Tribal Consultation Policy, which is available through the Commission's Policies webpage at http://www.fgc.ca.gov/policy/p4misc.aspx#tribal). Early tribal consultation with the Graton Rancheria Federation of Coast Miwok and Southern Pomo groups in September 2016. CDFW initiated communication with the tribe on issues concerning Pacific Herring management and the development of the FMP.

In addition, in July 2018, CDFW contacted NAHC to identify registered, Native American sacred sites in or within the vicinity of the project area and to obtain a list of tribes affiliated with the geographic area of the project. The results of the NAHC Sacred Lands File search indicate that Native American cultural sites are present within the project area. NAHC provided a list of Native American tribes who may have knowledge of cultural resources in the project area. On August 1, 2018, the Commission and CDFW sent a joint letter pursuant to PRC 21080.3.1 describing the project to Tribal representatives on the NAHC Tribal Consultation List requesting any input or concerns they might have regarding the project. The goal of the Commission and CDFW is to understand Tribal interests and concerns early in the project and to work collaboratively to resolve any concerns. No request for consultation has been submitted to CDFW to date. Correspondences related to tribal cultural resources are included in Appendix A.

Pacific Herring are a culturally important resource to many coastal tribes within the project area. The proposed project seeks to sustainably manage the herring resource and improve the long-term sustainability of the fishery. Any changes to the fishery that may affect tribal use will be addressed directly with the tribes through the consultation process.

XVIII. Utilities. Would the project:

a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. No land use changes or development are proposed as part of the project which would generate wastewater requiring treatment. Therefore, no impact would occur.

b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

No Impact. Implementation of the FMP and regulatory amendments would not include any facilities that would require water and would not increase the demand for water. In addition, the proposed project would not result in impact related to construction of new or expanded wastewater treatment facilities. Therefore, no impact would occur.

c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

No Impact. The proposed project involves the adoption of a Pacific Herring FMP and regulatory amendments to sustainably manage the herring resource and improve the long-term sustainability of the fishery. Implementation of the project would not result in land use change or development that would generate stormwater that would require the construction of new storm water drainage facilities or the expansion of existing facilities within the project area. Therefore, no impact would occur.

d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?

No Impact. Implementation of the FMP and regulatory amendments would not include any facilities that would require water and would not increase the demand for water. Therefore, no impact would occur.

e) Result in a determination by the wastewater treatment provider that serves or may serve the project that it has adequate capacity to serve the project's projected demand, in addition to the provider's existing commitments?

No Impact. See discussion under XVIII (a). There would be no impact related to wastewater treatment capacity.

f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?

No Impact. Although some solid waste is generated with fishing activities, implementation of the FMP and regulatory amendments would not result in an overall increase in solid waste generated by the fishery. Therefore, there would be no impact on landfill capacity.

g) Comply with federal, state, and local statutes and regulations related to solid waste?

No Impact. The proposed FMP and regulatory amendments would not result in a change in compliance with solid waste regulations. Therefore, no impact would occur.

h) Interfere with utilities?

No Impact. Fishing activities are not known to interfere with underwater cable or other submerged utilities. Therefore, no impact would occur.

XIX. Mandatory Findings of Significance.

a) Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of an endangered, rare, or threatened species, or eliminate important examples of the major periods of California history or prehistory?

Less Than Significant. As evaluated in this Initial Study, the proposed project would not substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of an endangered, rare, or threatened species, or eliminate important examples of the major periods of California history or prehistory. The proposed FMP and regulatory amendments would benefit the Pacific Herring fishery by adaptively managing it to ensure the long-term health of the resource. Pacific Herring would be removed from the project area by the commercial and recreational fisheries which could have impacts to the ecosystem. However, harvest of herring is strictly regulated and managed to minimize impacts to the ecosystem and other species. Therefore, this impact would be less than significant.

b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.)

Less Than Significant. The potential for adverse cumulative effects were considered in the response to each question in sections I through XIX of this Initial Study. As a result of this evaluation, there is no substantial evidence that there are adverse cumulative effects associated with the proposed project that would have significant impacts or require mitigation. Pursuant to the MLMA, this project in combination with past, present, and probable future projects would contribute to the conservation of marine ecosystems and marine living resources. Therefore, the proposed project would not add considerably to any cumulative impacts in the region. Therefore, cumulative impacts would be less than significant.

c) Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?

No Impact. The potential for adverse direct or indirect impacts to human beings were considered in the evaluation of environmental impacts for certain questions in sections I, III, VI, VIII, IX, XII, XIII, and XVI of this Initial Study. As a result of this evaluation, the proposed project would not have environmental effects that would cause substantial adverse direct or indirect effects on human beings. Therefore, no impact would occur.

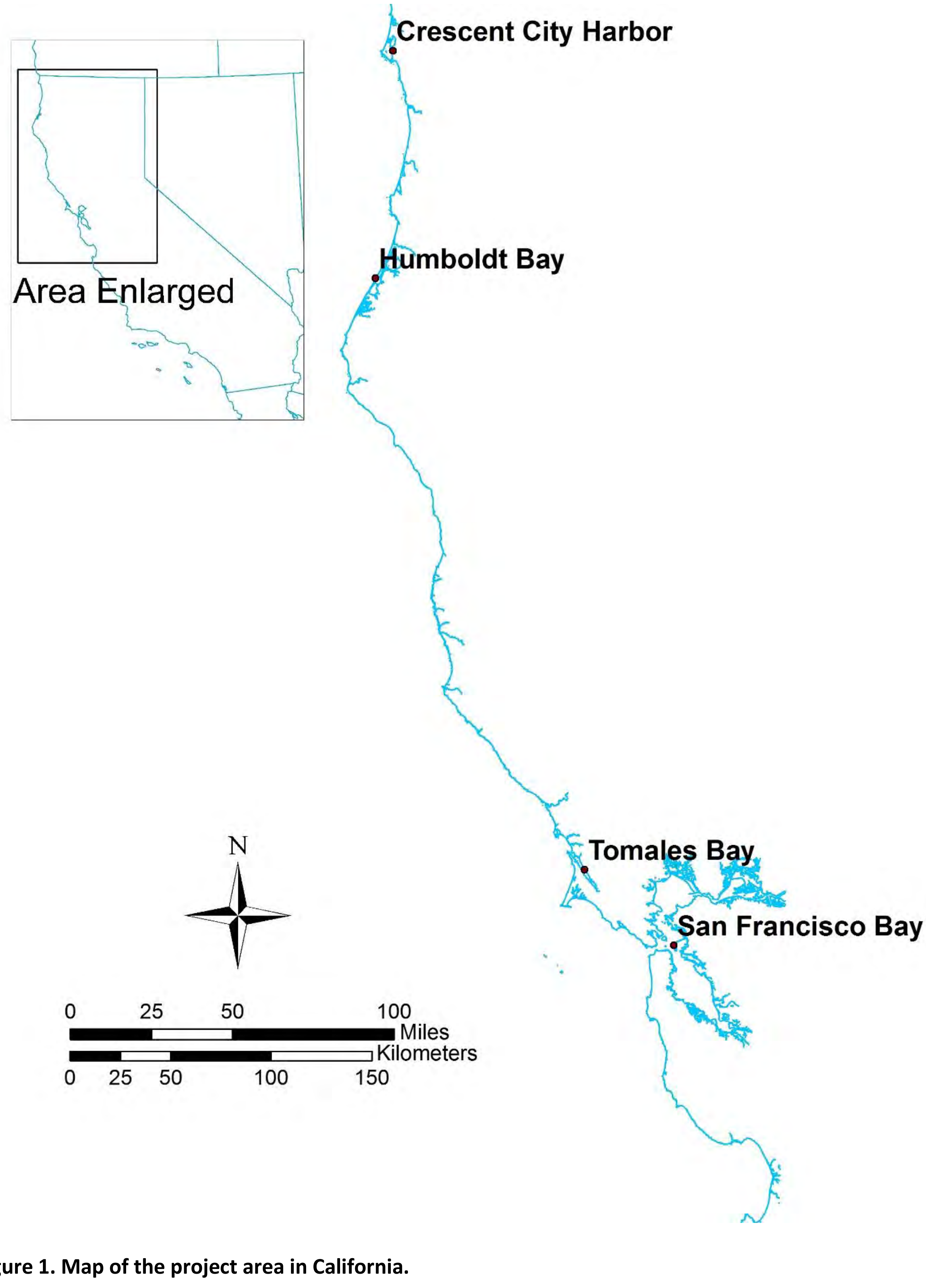

Figure 1. Map of the project area in California.

REFERENCES

Bay Area Air Quality Management District (Bay Area AQMD). 2017. California Environmental Quality Act Air Quality Guidelines. http://www.baaqmd.gov/~/media/files/planning-and-research/ceqa/ceqa_guidelines_may2017-pdf.pdf?la=en

California Air Resources Board (CARB). 2017. Area Designations Map/State and National. https://www.arb.ca.gov/desig/adm/adm.htm

California Department of Conservation. 2017. FMMP – Prime Farmland Definition. http://www.conservation.ca.gov/dlrp/fmmp/Pages/prime_farmland_fmmp.aspx

CDFW. 2018. 2018 Registered Aquaculturists, With Species And Services, By County, Public List. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3265

California Department of Toxic Substances. 2018. EnviroStor. https://www.envirostor.dtsc.ca.gov/public/

Caltrans. 2017. List of eligible and officially designated State Scenic Highways. http://www.dot.ca.gov/design/lap/livability/scenic-highways/

North Coast Unified Air Quality Management District (North Coast Unified AQMD). 2015. Regulations I Rule 110 – New Source Review (NSR) and Prevention of Significant Deterioration (PSD). https://www.arb.ca.gov/drdb/ncu/curhtml/R110.PDF

United States Environmental Protection Agency (USEPA). 2018. Status of California Designated Areas. https://www3.epa.gov/airquality/urbanair/sipstatus/reports/ca_areabypoll.html

United States Coast Guard. Navigation Center, US Department of Homeland Security. https://www.navcen.uscg.gov/?pageName=Rule26

APPENDIX A

Correspondence Related to Tribal Cultural Resources

California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

STATE OF CALIFORNIA
EDMUND G. BROWN JR., GOVERNOR

NATURAL RESOURCES AGENCY

California Department of Fish and Wildlife
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109

August 1, 2018

Honorable [Name, Title]
[Tribe name]
[Address]
[City, State Zip]

Subject: Notification Pursuant to California Environmental Quality Act Section 21080.3.1 of California Pacific Herring Fishery Management Plan

Dear Honorable Tribal Representative:

The California Fish and Game Commission (Commission) and the California Department of Fish and Wildlife (Department) would like to inform you as a tribal representative that the Commission is proposing development of a California Pacific Herring Fishery Management Plan (Project), including changes to regulations in Title 14 of the California Code of Regulations. The Commission is providing this formal notice as the Project lead agency pursuant to the California Environmental Quality Act (CEQA, Public Resources Code Section 21080.3.1).

Your input on the proposed Project can be provided to the Commission through consultation pursuant to CEQA sections 21080.3.1 and 21080.3.2 or during the public comment period planned to begin in August 2018. The Commission and the Department welcome direct communication and consultation prior to the public process on this proposed Project and any anticipated impacts on tribal interests or cultural resources.

The proposed Project would develop a comprehensive management strategy for Pacific herring (*Clupea pallasi*) through a fishery management plan (FMP), which may be of interest to your tribe. The proposed Project area is located within San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor.

FMP development will include proposed changes to the California Code of Regulations, Title 14, sections 27.60, 28.60, 163, 163.5 and 164; these sections regulate the harvest of Pacific herring for the recreational and commercial fisheries in California. The Department previously reached out to your tribe on this same project with letters sent on July 18, 2016, and March 28, 2018. The FMP will be responsive to environmental and socioeconomic changes using a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem. The Department has outlined a number of management objectives for the FMP, which include:

- Consider the role of herring as a forage fish within the wider ecosystem
- Modernize the limited entry permit system

- Develop a harvest control rule for the San Francisco Bay fishery
- Create a framework for collaborative research in the northern fishing areas
- Update and streamline existing commercial regulations
- Develop recreational fishing regulations

The goal of the Commission and the Department is to understand tribal interests and concerns early in the proposed Project and to work collaboratively to resolve any concerns. The Commission's Tribal Consultation Policy can be viewed at http://www.fgc.ca.gov/policy/p4misc.aspx. The Department is committed to open communication with your tribe under its Tribal Communication and Consultation Policy, which is available through the Department's Tribal Affairs webpage at https://www.wildlife.ca.gov/General-Counsel/Tribal-Affairs.

If you would like more information on the proposed Project, please contact Kirsten Ramey at Kirsten.Ramey@wildlife.ca.gov or 707-445-5365. To request formal consultation with the Commission on the Project pursuant to CEQA section 21080.3.1, please respond in writing within 30 days to Executive Director Valerie Termini at Valerie.Termini@fgc.ca.gov or California Fish and Game Commission, P.O. Box 944209, Sacramento, CA 94244. To request consultation with the Department, please contact Tribal Liaison Nathan Voegeli at Tribal.Liaison@wildlife.ca.gov or Department of Fish and Wildlife, P.O. Box 944209, Sacramento, CA 94244. Please be sure to designate and provide contact information for the appropriate lead contact person.

We look forward to your response and input into the proposed Project.

Sincerely,

Valerie Termini Executive Director California Fish and Game Commission	Craig Shuman, D. Env. Marine Regional Manager California Department of Fish and Wildlife

ec: California Department of Fish and Wildlife

Nathan Voegeli, Tribal Liaison
Office of General Counsel
Tribal.Liaison@wildlife.ca.gov

Kirsten Ramey, Program Manager
Marine Region
Kirsten.Ramey@wildlife.ca.gov

Tribal Distribution List

STATE OF CALIFORNIA — Edmund G. Brown, Jr., Governor

NATIVE AMERICAN HERITAGE COMMISSION
Environmental and Cultural Department
1550 Harbor Blvd., ROOM 100
West SACRAMENTO, CA 95691
(916) 373-3710
Fax (916) 373-5471

July 25, 2018

Kirsten Ramey
California Department of Fish & Wildlife

Sent by Email: Kirsten.Ramey@wildlife.ca.gov

Re : California Pacific Herring Fishery Management Plan, Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, Alameda and Contra Costa Counties

Dear Ms. Ramey,

A record search of the Native American Heritage Commission (NAHC) Sacred Lands File (SLF) was completed for the information you have submitted for the above referenced project. The results indicate Native American cultural sites are present. Please contact the tribes and individuals lists on the "Sacred Lands File Results Contact List". Other sources for cultural resources should also be contacted for information regarding known and/or recorded sites.

Enclosed is a list of Native American tribes who may also have knowledge of cultural resources in the project area. I suggest you contact all of those indicated, if they cannot supply information, they might recommend others with specific knowledge. By contacting all those listed, your organization will be better able to respond to claims of failure to consult with the appropriate tribe. If a response has not been received within two weeks of notification, the Commission requests that you follow-up with a telephone call to ensure that the project information has been received.

If you receive notification of change of addresses and phone numbers from any of these tribes, please notify me. With your assistance we are able to assure that our lists contain current information. If you have any questions or need additional information, please contact me at frank.lienert@nahc.ca.gov.

Sincerely,

Frank Lienert
Associate Governmental Program Analyst

Sacred Lands File Results Contact List

Tolowa Dee Ni' (Smith River Rancheria)

(see tribal contact list)

Amelia Brown

PO BOX 1

Smith River, CA 95567

Sam Lopez

PO Box 10

Smith River, CA 95567

Ed Lopez

PO Box 1

Smith River, CA 95567;

Dorothy Habeman

Old Arcata Road,

Eurkea, CA 95501

Florence Shaughnessy

PO Box 478

Klamath, CA 95548

Carrie Hodge Gilbert

PO Box 13

Requa, Crescent City, CA

Francis White

PO Box 236

Orick, CA 95555

Walt Lara Sr.

PO Box 516

Trinidad, CA 95570

707-488-3754

Margaret Lara

PO Box 405

Orick, CA 95555

707-488-5531

NICPA

PO Box 876

Trinidad, CA 95570

707-677-0122

Cher-Ae Heights Indian Community of the Trinidad Rancheria

(See tribal contact list)

Wiyot Tribe

(See tribal contact list)

Sacred Lands File Results Contact List

Cahto Tribe

(See tribal contact list)

Manchester Band of Pomo Indians

(See tribal contact list)

Kashia Band of Pomo Indians

(See tribal contact list)

Amah Mutsun Tribal band

(See tribal contact list)

The Ohlone Indian Tribe

(See tribal contact list)

Costanoan Rumsen Carmel Tribe

(see tribal contact list)

Ohlone Costanoan-Esselen Nation

(See tribal contact list)

Linda G. Yamane

1585 Mira Mar Ave.

Seaside, CA 93955

831-394-5915

Native American Heritage Commission
Native American Contacts
July 25, 2018

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vmoorehead@earthlink.net
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(707) 826-1737 - Fax

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bmobbs@bluelakerancheria-nsn.gov
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(707) 668-4272 Fax

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(707) 894-5775
(707) 894-5727

Drv Creek Rancheria Band of Pomo Indians
Chris Wriaht. Chairperson
P.O. Box 607 — Pomo
Gevserville, CA 95441
(707) 522-4233
(707) 522-4286

Elk Vallev Rancheria
Dale Miller. Chairperson
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Crescent Citv, CA 95531
dmiller@elk-vallev.com
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(707) 464-4519

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(707) 462-9183 Fax

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(530) 625-4594 Fax

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(707) 744-1506

Karuk Tribe
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510-701-3975

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Native American Heritage Commission
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July 25, 2018

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Environmental@cahto.ora
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(707) 984-6201 Fax
Cahto
Kato
Pomo

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(707) 882-3417 Fax
Pomo

Middletown Rancheria
Jose Simon III. Chairperson
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Pomo
Lake Miwok

Pinoleville Pomo Nation
Leona Willams. Chairperson
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Ukiah , CA 95482
(707) 463-1454
(707) 463-6601 Fax
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Potter Vallev Tribe
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(707) 462-1240 - Fax
Pomo

Redwood Vallev or Little River Band of Pomo Indiai
Debra Ramirez. Chairperson
3250 Road I
Redwood Vallev , CA 95470
rvrsecretarv@comcast.net
(707) 485-0361
(707) 485-5726 Fax
Pomo

Resiahini Rancheria
Rick Dowd. Chairperson
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(707) 482-3425 Fax
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(707) 733-1727 Fax
Wivot
Mattole

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James Russ. President
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tribalcouncil@rvit.ora
(707) 983-6126
(707) 983-6128 Fax
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Pit River
Pomo
Concow
Wailaki: Wintun

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Native American Heritage Commission
Native American Contacts
July 25, 2018

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Native American Heritage Commission
Native American Contacts
July 25, 2018

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Native American Heritage Commission
Native American Contacts
July 25, 2018

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Blue Lake Rancheria
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NAGPRA Coordinator
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(707) 954-5355
(707) 482-1377

Muwekma Ohlone Indian Tribe of the SF Bay Area
Rosemary Cambra, Chairperson
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Indian Canyon Mutsun Band of Costanoan
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Sonoma, Mendocino, Humboldt, Del Norte, Alameda and Contra Costa Counties

Native American Heritage Commission
Native American Contacts
July 25, 2018

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Federated Indians of Graton Rancheria
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Xolon-Salinan Tribe
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Salinan Tribe of Monterev, San Luis Obispo Counties
Fredrick Segobia
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Muwekma Ohlone Indian Tribe of the SF Bav Area
Rosemarv Cambra, Chairperson
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(510) 581-5194

Covote Vallev Band of Pomo Indians
Michael Hunter, Chairperson
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Redwood Valle , CA 95470
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Federated Indians of Graton Rancheria
Grea Sarris, Chairperson
6400 Redwood Drive, Ste 300 — Coast Miwok
Rohnert Park , CA 94928 — Southern Pomo
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APPENDIX B

Hazardous Material Sites

Site/Facility Name	Envirostor ID	Address Description	City	Zip	County
1450 MARIN ST. LLC PROJECT / FEDERATED FRY METALS	38330005	1901 CESAR CHAVEZ	SAN FRANCISCO	94124	SAN FRANCISCO
ACTION PLATING (2W)	1340116	10132 EDES AVENUE	OAKLAND	94603	ALAMEDA
AMCO CHEMICAL	1390001	1414 THIRD STREET	OAKLAND	94607	ALAMEDA
ARLENE'S CLEANERS	60001242	2017 CHESTNUT STREET	SAN FRANCISCO	94123	SAN FRANCISCO
BAYVIEW PLUME STUDY AREA	70000015	NEAR INTERSECTION OF SHAFTER AVENUE AND HAWES STREET	SAN FRANCISCO	94124	SAN FRANCISCO
BLAIR SOUTHERN PACIFIC LANDFILL	7490012	AT THE FOOT OF SOUTH 51ST STREET	RICHMOND	94804	CONTRA COSTA
CAL TECH METALS	1340118	825, 829, 841 31ST STREET	OAKLAND	94608	ALAMEDA
CALTRANS/SSF MAINTENANCE STATION	41280108	166 HARBOR WAY	S SAN FRANCISCO	94080	SAN MATEO
CATERPILLAR INC	1350119	800 DAVIS STREET	SAN LEANDRO	94577	ALAMEDA
CINTAS/DEDOMENICO SITE	1890017	777 139TH AVENUE	SAN LEANDRO	94578	ALAMEDA
COMMERCIAL BUILDINGS	1720110	1250-1276, 1284 W. GRAND & 2232 POPLAR	OAKLAND	94607	ALAMEDA
COOPER CHEMICAL	7280154	2801 GIANT ROAD	RICHMOND	94806	CONTRA COSTA
DEL NORTE PESTICIDE STORAGE	8420001	2650 W WASHINGTON BLVD	CRESCENT CITY	95531	DEL NORTE
DREW SALES	7500035	1156 CASTRO STREET	RICHMOND	94804	CONTRA COSTA
DUTCH BOY #3	1390006	4825 SAN LEANDRO STREET	OAKLAND	94601	ALAMEDA
DWA PLUME	1990002	SAN LEANDRO (GROUNDWATER CONTAMINATION)	SAN LEANDRO	94578	ALAMEDA
E-D COAT INC	60002501	715 4TH STREET	OAKLAND	94607	ALAMEDA
ELECTRO FORMING CO. - RICHMOND	1330044	130 NEVIN AVENUE	RICHMOND	94801	CONTRA COSTA
FASS METALS	7330030	818 W. GERTRUDE AVENUE	RICHMOND	94801	CONTRA COSTA
FMC CORPORATION - RICHMOND	7280011	855 PARR BLVD	RICHMOND	94801	CONTRA COSTA
FORMER J. H. BAXTER FACILITY, ALAMEDA	1240036	2189, 2199, 2201, 2229 CLEMENT AVENUE	ALAMEDA	94501	ALAMEDA
GENERAL ELECTRIC - OAKLAND	1360059	5441 EAST 14TH STREET	OAKLAND	94601	ALAMEDA
HARBORFRONT TRACT	70000178	MEADE SOUTH 49TH EAST MONTGOMERY	RICHMOND	94804	CONTRA COSTA
HARBOUR WAY SOUTH	7340024	738 HARBOUR WAY SOUTH	RICHMOND	94804	CONTRA COSTA
HARD CHROME ENGINEERING	1870003	750 107TH AVENUE	OAKLAND	94603	ALAMEDA

HARRIS DRY CLEANERS	1720109	2801 MARTIN LUTHER KING JR. WAY	OAKLAND	94609	ALAMEDA
HOWARD MARINE TERMINAL SITE	1440006	EMBARCADERO WEST AND MARKET STREETS	OAKLAND	94604	ALAMEDA
IKEA (FORMER BARBARY COAST)	1440005	4300 EASTSHORE HIGHWAY	EMERYVILLE	94608	ALAMEDA
JENKINS AUTO WRECKERS	1750025	1778 10TH STREET	OAKLAND	94607	ALAMEDA
KAISER AEROSPACE & ELECTRONICS COMPANY	1990015	880 DOOLITTLE DRIVE	SAN LEANDRO	94577	ALAMEDA
LANE METAL FINISHERS	60000594	2942 SAN PABLO AVENUE	OAKLAND	94608	ALAMEDA
LIQUID GOLD OIL CORP	7290039	HOFFMAN BLVD & S 47TH ST	RICHMOND	94804	CONTRA COSTA
MACDONALD SAN PABLO WALL 45TH PLUME	60000506	SAN PABLO WALL 45TH PLUME	EL CERRITO AND RICHMOND	94804	CONTRA COSTA
MARCHANT/WHITNEY	60001628	5679 HORTON STREET	EMERYVILLE	94608	ALAMEDA
MCNAMARA AND PEEPE LUMBER MILL	12240115	1619 GLENDALE DRIVE	ARCATA	95521	HUMBOLDT
MYERS DRUM - EMERYVILLE	1340110	4500 SHELLMOUND STREET	EMERYVILLE	94608	ALAMEDA
NORTHWESTERN VENETIAN SUPPLY CORP. SITE	1340123	1218 24TH STREET	OAKLAND	94607	ALAMEDA
PORT OF OAKLAND - EMBARCADERO COVE	1510021	DENNISON AND EMBARCADERO STREETS	OAKLAND	94606	ALAMEDA
PORT OF OAKLAND, BERTH 25 AND 26	1280092	2500 7TH STREET	OAKLAND	94607	ALAMEDA
PORT OF RICHMOND (SHIPYARD #3)	7370030	1312 CANAL BLVD	RICHMOND	94804	CONTRA COSTA
REACTION PRODUCTS	7280013	840 MORTON AVENUE	RICHMOND	94806	CONTRA COSTA
RICHMOND TOWNHOUSE APARTMENTS	7990005	2887 AND 2989 PULLMAN AVENUE	RICHMOND	94804	CONTRA COSTA
SCHLAGE LOCK COMPANY	38340157	BAYSHORE BLVD AND SUNNYDALE AVE.	SAN FRANCISCO	94134	SAN FRANCISCO
SHERWIN WILLIAMS	60000189	1450 SHERWIN AVENUE	EMERYVILLE	94608	ALAMEDA
SINGER FRIDEN	1360094	2350 AND 2450 WASHINGTON AVENUE	SAN LEANDRO	94577	ALAMEDA
SOUTHERN PACIFIC - BRISBANE (NORTH AREA)	41490037	GENEVA AVENUE AND BAYSHORE BOULEVARD	BRISBANE	94005	SAN MATEO
SOUTHERN PACIFIC -WEST OAKLAND RAIL YARD	1400010	CYPRESS CORRIDOR	OAKLAND	94607	ALAMEDA
UNION PACIFIC OAKLAND COLISEUM SITE	1400015	700 73RD AVENUE	OAKLAND	94621	ALAMEDA
UNITED HECKATHORN	7280015	8TH & WRIGHT	RICHMOND	94804	CONTRA COSTA
UNIVERSITY OF CALIFORNIA, RICHMOND SE	7730003	1301 SOUTH 46TH STREET	RICHMOND	94804	CONTRA COSTA
ZENECA RICHMOND AG PRODUCTS	7280002	1415 SOUTH 47TH STREET	RICHMOND	94804	CONTRA COSTA

September 20, 2018

California Department of Fish and Wildlife
Attn: Ryan Bartling, Environmental Scientist
5355 Skylane Blvd, Suite B
Santa Rosa, CA 95403
Via electronic delivery to: Ryan.Bartling@wildlife.ca.gov

Re: Comments on the Pacific Herring Fishery Management Plan Scoping

Dear Mr. Bartling,

The Environmental Action Committee of West Marin is based in Point Reyes Station and has been working to protect the unique lands, waters, and biodiversity of West Marin since 1971. Since our inception, we have been committed to the health of Tomales Bay. We submit these brief comments in regard to the Pacific Herring Fishery Management Plan (herring FMP), specifically as it relates to Tomales Bay.

Regarding the scope of the herring FMP, we request that the herring FMP addresses the following: 1) updates to the current commercial limits, 2) updates to the current recreational limits, and 3) whether additional research is needed to make these updates. In addressing the above three points, the herring FMP should consider direct and indirect environmental impacts to the Pacific herring (herring) fishery and other fisheries, to wildlife including special status bird species and protected marine mammals, cumulative impacts, and changing climate conditions.

Based on our knowledge of the historic Tomales Bay fishery, we also present our recommendations for recreational and commercial limits on the herring fishery, when additional research is needed, and how this research should be conducted.

Environmental Action Committee of West Marin | PO Box 609, Point Reyes Station, CA 94956
415-663-9312 | admin@eacmarin.org | www.eacmarin.org

We support the Pacific Herring Steering Committee (Committee)'s management objective as part of the herring FMP to "update existing commercial herring regulations where possible."[1] Many of these regulations are woefully out of date and are based on historic numbers and landings.

In regard to commercial regulation updates, we recommend that the commercial regulations be updated so that Tomales Bay is closed to commercial herring fishing due to a number of factors including extremely low herring numbers, environmental considerations, and poor market conditions. The current commercial season limit or quota is 350 tons[2], which is outdated since no commercial fishing has taken place in the Bay since 2007.[3] Furthermore, the most recent commercial herring fishing efforts in Tomales Bay resulted in dead unsalable fish and/or very low pricing in part due to poor market conditions.

Following the proposed closure of the Tomales Bay herring fishery, any future decisions to reopen the Tomales Bay herring fishery should only be made after a comprehensive and scientifically based assessment and analysis is made of the herring stocks, current and future spawning estimates, biomass, etc. led by qualified Department of Fish and Wildlife staff and/or other trained and independent researchers, with the involvement of multiple stakeholders. Regarding the Committee's management objective to "[d]evelop *collaborative* research opportunities to monitor and assess herring populations in Tomales Bay…"[4] we request that these opportunities are truly collaborative and include stakeholders representative of multiple interests including local West Marin fisherman, individuals from non-extractive industries, and environmental organizations.

Any future analysis to consider whether to reopen the Tomales Bay herring fishery should take into consideration all recent research including Dr. John Kelly's June 2018 paper *Echoes of Numerical Dependence: Responses of Wintering Waterbirds to Pacific Herring Spawns*, which found a functional relationship between water bird numbers and the availability of herring.[5]

We also support the Committee's management objective as part of the herring FMP to "[d]evelop regulations for the recreational herring fishery."[6] Regarding the recreational fishery in

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[1] *See* California Department of Fish and Wildlife, *Pacific Herring Fishery Management Plan*, *available at*:
https://wildlife.ca.gov/Fishing/Commercial/Herring/FMP
[2] *See* California Department of Fish and Wildlife, 2017-*18 California Commercial Herring Fishery FAQ Sheet*, *available at*:
https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=151147&inline
[3] *See* California Department of Fish and Wildlife, *State-Managed California Commercial Pacific Herring Fishery*, *available at*: https://www.wildlife.ca.gov/Fishing/Commercial/Herring
[4] *See* California Department of Fish and Wildlife, *Pacific Herring Fishery Management Plan*, *emphasis added*, *available at*:
https://wildlife.ca.gov/Fishing/Commercial/Herring/FMP
[5] *See* John P. Kelly, *et al.*, *Echoes of Numerical Dependence: Responses of Wintering Waterbirds to Pacific Herring Spawns*, Marine Ecology Progress Series, June 11, 2018, page 253.
[6] *See* California Department of Fish and Wildlife, *Pacific Herring Fishery Management Plan*, *available at*:

Tomales Bay, consistent with the Fish and Game Commission Marine Resource Committee's July 2018 recommendation to limit recreational herring take and the submitted comments, we recommend a limit of two five-gallon buckets per day, which is approximately 75 lbs. A volume limit is preferable as most fishermen do not carry scales.

In closing, we also support the Committee's management objective to "[d]escribe habitat and ecosystem considerations"[7] in the herring FMP, and we thank you for your consideration of our comments.

Sincerely,

Morgan Patton
Executive Director

Ashley Eagle-Gibbs
Conservation Director

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https://wildlife.ca.gov/Fishing/Commercial/Herring/FMP
[7] *See id.*

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

July 5, 2016

Contact name
Tribal group name
Address

Dear Honorable Tribal Representative:

The California Department of Fish and Wildlife (Department) would like to inform you as a tribal representative that its Marine Region staff will be developing a Fishery Management Plan (FMP) for California's Pacific herring fishery, in accordance with Fish and Game Code sections 7070-7072 and provisions of the Marine Life Management Act (MLMA). Your input can be provided to the Department through direct communication and consultation or during the established opportunities for public involvement scheduled to begin in mid-2016. The Department would welcome direct communication and consultation on this proposed Project and any anticipated impacts on Tribal interests.

The MLMA establishes a statutory framework for sustainably managing California's ocean fisheries through the use of a FMP. The MLMA further requires that marine fisheries management be based on both the best available science as well as stakeholder input. The primary goal of the FMP will be to formalize a management strategy for Pacific herring which will be responsive to environmental and socioeconomic changes. It will also establish a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem. The Department has outlined a number of initial management objectives for the FMP process which include the following:

- Review and update the limited entry permit system to reflect the needs of the modern commercial fleet
- Streamline and modernize existing herring regulations where possible
- Develop a Harvest Control Rule for the San Francisco Bay fishery that sustains a commercial fleet, accounts for ecosystem considerations, and reflects current precautionary management
- Develop regulations for the recreational herring fishery
- Describe herring spawning habitat and associated management efforts statewide and provide recommendations for agency coordination for habitat management
- Develop collaborative research protocols and requirements for commercial herring fishing activities in Tomales Bay, Crescent City Harbor, and Humboldt Bay.

An overview of current management efforts for Pacific herring can be found on the Departments web site: https://www.wildlife.ca.gov/Fishing/Commercial/Herring

The Department is committed to understanding your Tribe’s interest in development of the Pacific herring FMP prior to beginning our outreach with the general public. Our desire is to collaboratively address your interests early in the process.

The Department would welcome the opportunity to discuss our plans for developing the FMP. Your input would be especially helpful before August 2016, so that it can be considered before we begin conversations with the general public. Please contact Mr. Tom Barnes, Department of Fish and Wildlife, with your thoughts or comments. Mr. Barnes may be contacted by email at Tom.Barnes@wildlife.ca.gov, or by telephone at (858) 467-4233. If you would like to request formal government-to-government consultation, please contact Mr. Nathan Voegeli, Tribal Liaison, by email, tribal.liaison@wildlife.ca.gov, or by phone, (916) 651-7653.

We look forward to receiving your input.

Sincerely,

Craig Shuman, D. Env.
Regional Manager, Marine Region

ec: Nathan Voegeli, Attorney and Tribal Liaison
Department of Fish and Wildlife
tribal.liaison@wildlife.ca.gov

Valerie Termini, Executive Director
California Fish and Game Commission
Valerie.Termini@fgc.ca.gov

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

March 28, 2018

[Contact name
Tribal group name
Address]

Dear Honorable Tribal Representative:

In July 2016, the California Department of Fish and Wildlife (Department) sent a letter to notify you that the Marine Region will be developing a Fishery Management Plan (FMP) for California's Pacific Herring (Herring) fishery, in accordance with Fish and Game Code sections 7070-7072 and provisions of the Marine Life Management Act. We are writing to provide an update on the status of the FMP, and to request your input, which will be integrated into a draft FMP. The Department continues to be committed to understanding [Tribe's] interest in Herring management, and welcomes direct communication and consultation on the FMP project.

During the two past years, the Department has worked with tribal communities, stakeholders, and industry partners to develop a comprehensive management strategy for Herring, which will be responsive to environmental and socioeconomic changes. The FMP will include a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem.

The Department has outlined a number of management objectives for the FMP, which include the following:

- Review and update the limited entry permit system to reflect the needs of the modern commercial fleet
- Develop a Harvest Control Rule for the San Francisco Bay fishery that sustains a commercial fleet, incorporates ecosystem indicators, and reflects current precautionary management
- Formalize the decision making process to set yearly commercial fishery quotas
- Develop regulations for the recreational Herring fishery
- Improve the description of Herring spawning habitat and associated statewide habitat management efforts and provide recommendations for habitat management
- Develop collaborative research protocols and requirements for commercial Herring fishing activities in Tomales Bay, Crescent City Harbor, and Humboldt Bay.

An overview of current management efforts for Herring can be found on the Department's web site: www.wildlife.ca.gov/Fishing/Commercial/Herring

The Department continues to seek tribal input on the Herring FMP process and to work collaboratively to resolve any concerns. We welcome your feedback and input before August 31, 2018, so that the Department can consider it before developing a final draft of the FMP for public review. The FMP is expected to be submitted to the Fish and Game Commission at the October 16-17, 2018, meeting and is scheduled for possible adoption at the December 12-13, 2018 meeting.

Please contact Ms. Kirsten Ramey, Department of Fish and Wildlife, by email at Kirsten.Ramey@wildlife.ca.gov, or by telephone at 707-445-5365 with comments or questions. If you would like to request formal government-to-government consultation, please contact Mr. Nathan Voegeli, Tribal Liaison, by email, tribal.liaison@wildlife.ca.gov, or by telephone at 916-651-7653.

We look forward to receiving your input and working together to ensure tribal interests and priorities are reflected in the Herring FMP.

Sincerely,

Craig Shuman, D. Env.
Marine Regional Manager

ec: Kirsten Ramey, Senior Environmental Scientist Supervisor
Marine Region
Kirsten.Ramey@wildlife.ca.gov

Nathan Voegeli, Attorney and Tribal Liaison
Office of General Counsel
tribal.liaison@wildlife.ca.gov

Valerie Termini, Executive Director
California Fish and Game Commission
Valerie.Termini@fgc.ca.gov

STATE OF CALIFORNIA
EDMUND G. BROWN JR., GOVERNOR

NATURAL RESOURCES AGENCY

California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

California Department of Fish and Wildlife
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109

August 1, 2018

Honorable [Name, Title]
[Tribe name]
[Address]
[City, State Zip]

Subject: Notification Pursuant to California Environmental Quality Act Section 21080.3.1 of California Pacific Herring Fishery Management Plan

Dear Honorable Tribal Representative:

The California Fish and Game Commission (Commission) and the California Department of Fish and Wildlife (Department) would like to inform you as a tribal representative that the Commission is proposing development of a California Pacific Herring Fishery Management Plan (Project), including changes to regulations in Title 14 of the California Code of Regulations. The Commission is providing this formal notice as the Project lead agency pursuant to the California Environmental Quality Act (CEQA, Public Resources Code Section 21080.3.1).

Your input on the proposed Project can be provided to the Commission through consultation pursuant to CEQA sections 21080.3.1 and 21080.3.2 or during the public comment period planned to begin in August 2018. The Commission and the Department welcome direct communication and consultation prior to the public process on this proposed Project and any anticipated impacts on tribal interests or cultural resources.

The proposed Project would develop a comprehensive management strategy for Pacific herring (*Clupea pallasi*) through a fishery management plan (FMP), which may be of interest to your tribe. The proposed Project area is located within San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor.

FMP development will include proposed changes to the California Code of Regulations, Title 14, sections 27.60, 28.60, 163, 163.5 and 164; these sections regulate the harvest of Pacific herring for the recreational and commercial fisheries in California. The Department previously reached out to your tribe on this same project with letters sent on July 18, 2016, and March 28, 2018. The FMP will be responsive to environmental and socioeconomic changes using a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem. The Department has outlined a number of management objectives for the FMP, which include:

- Consider the role of herring as a forage fish within the wider ecosystem
- Modernize the limited entry permit system

- Develop a harvest control rule for the San Francisco Bay fishery
- Create a framework for collaborative research in the northern fishing areas
- Update and streamline existing commercial regulations
- Develop recreational fishing regulations

The goal of the Commission and the Department is to understand tribal interests and concerns early in the proposed Project and to work collaboratively to resolve any concerns. The Commission's Tribal Consultation Policy can be viewed at http://www.fgc.ca.gov/policy/p4misc.aspx. The Department is committed to open communication with your tribe under its Tribal Communication and Consultation Policy, which is available through the Department's Tribal Affairs webpage at https://www.wildlife.ca.gov/General-Counsel/Tribal-Affairs.

If you would like more information on the proposed Project, please contact Kirsten Ramey at Kirsten.Ramey@wildlife.ca.gov or 707-445-5365. To request formal consultation with the Commission on the Project pursuant to CEQA section 21080.3.1, please respond in writing within 30 days to Executive Director Valerie Termini at Valerie.Termini@fgc.ca.gov or California Fish and Game Commission, P.O. Box 944209, Sacramento, CA 94244. To request consultation with the Department, please contact Tribal Liaison Nathan Voegeli at Tribal.Liaison@wildlife.ca.gov or Department of Fish and Wildlife, P.O. Box 944209, Sacramento, CA 94244. Please be sure to designate and provide contact information for the appropriate lead contact person.

We look forward to your response and input into the proposed Project.

Sincerely,

Valerie Termini
Executive Director
California Fish and Game Commission

Craig Shuman, D. Env.
Marine Regional Manager
California Department of Fish and Wildlife

ec: California Department of Fish and Wildlife

Nathan Voegeli, Tribal Liaison
Office of General Counsel
Tribal.Liaison@wildlife.ca.gov

Kirsten Ramey, Program Manager
Marine Region
Kirsten.Ramey@wildlife.ca.gov

California Commercial Pacific Herring Fishery Permit Survey
California Department of Fish and Wildlife

Please complete and return this survey by **July 31, 2017** or complete online using your herring permit number: **wildlife.ca.gov/HerringSurvey**

1. How long have you participated in the herring fishery (as crew or permit holder)?			Years:
2. How many crewmembers did you employ when you last fished your permit?			Number:
3. If you own a herring fishing vessel, what size is it?	Length: ft	Beam: ft	Capacity: tn

Currently, herring permits are issued to an individual, and that individual may apply to the Department to temporarily substitute their permit to someone else.

Please check the box that best describes your opinion about these potential changes:	**Yes**	**No**	**Not Sure**	**No Opinion**
4. Should permit holders be allowed to substitute their permit to another person?				
5. Should permits be assigned to a herring fishing vessel rather than an individual, as is common in many other state-managed fisheries?				
6. As permits become available, should preferential status be given to new entrants who have participated in the fishery as crew?				
Please explain your responses:				

The FMP presents an opportunity to modify the regulatory language in Section 163 of the California Code of Regulations.

Please check the box that best describes your opinion about these potential changes:	**Yes**	**No**	**Not Sure**	**No Opinion**
7. Are you in favor of modifying the requirements for vessel identification (163(d))?				
8. Are you in favor of modifying the requirements for marking gill nets 163(f)2(F).				
9. Are you in favor of modifying the requirements for gill net tending in San Francisco Bay (163(f)2(A)?				
10. Are you in favor of modifying the process for measuring mesh size, as currently described in 163(f)2(B)?				
Please provide suggestions for how regulatory language should be modified, consistent with the Dept.'s mission of resource protection. You may enclose extra sheets of paper when you return your survey.				

11. Are you interested in participating in discussions about designing a collaborative research protocol for use in areas outside SF Bay? Check one: Yes_____ No_____

Questions 12-17 are specific to the San Francisco Bay fishery.
The platoon fishing system was instituted in San Francisco Bay to minimize conflict and organize a much larger fleet. There is interest in streamlining the permit process by eliminating the Odd and Even platoons. Currently, each Odd or Even permit allows the holder to fish 65 fathoms (1 shackle) of gillnet every other week during the season.

DHAC proposal to eliminate platoons: Each Odd or Even permit could be converted to a single standard “Gillnet” permit, which would entitle the holder to fish a half shackle (32.5 fathoms) of gear every week during the season. CH permits could be converted to 2 standard gillnet permits equaling 1 shackle. These changes would not reduce the amount of gear currently allowed in the fishery.

Existing regulations allow herring permittees to hold up to 3 permits. If the platoon system were eliminated (as described above), the Department may consider allowing participants to hold up to 4 permits, each allowing use of a half shackle of gear (2 shackles total). The Department may then consider allowing these new 4-permit holders to convert to a single “full permit” to further simplify the permitting system.

Please check the box that best describes your opinion about these proposed changes:	**Yes**	**No**	**Not Sure**	**No Opinion**
12. Are you in favor of eliminating the platoon system?				
13. Are you in favor of converting to standardized gear permits that allow the holder to fish a half shackle of gillnet every week of the season?				
14. If the system described above is implemented, should permit holders be allowed to substitute their permits?				
15. Would you support allowing participants to own up to 4 permits?				
16. Would you support the issuance of “full permits” to those who hold 4 permits?				
Please explain your responses:				

17. Do you have other suggestions for modifying the platoon system? If so, please describe here:

18. In your opinion, what is a viable fleet size for the herring fishery given resource conditions, herring markets, and fishing area constraints for San Francisco Bay?
    Number of vessels_____ Number of full shackles per vessel_____

19. In your opinion, what is the minimum viable quota for the season (i.e., below this number, it doesn’t make sense to fish)? _____tons

20. If you would like to provide other comments about permitting or regulatory issues in the herring fishery, please return along with this survey in the envelope provided**.**

Thank you for completing this survey.

Appendix R Harvest Control Rule Framework Development and Guidance for Amending the Decision Tree

Introduction

During the process to develop a Fishery Management Plan (FMP) for Pacific Herring, *Clupea pallasii*, (Herring), the Steering Committee (SC) agreed that the preferred Harvest Control Rule (HCR) (Figure R-1, also see Appendix M) would be used to set a preliminary quota each year based on the estimated biomass of Herring in San Francisco Bay. The SC also proposed a framework wherein a preliminary quota could be modified each year based on a suite of environmental and ecosystem indicators, with quota increases recommended when ecosystem conditions are good (Figure R-2; green), moderate quota reductions recommended when ecosystem conditions warrant precaution (Figure R-2; yellow), and larger reductions warranted during extreme conditions (Figure R-2; red).

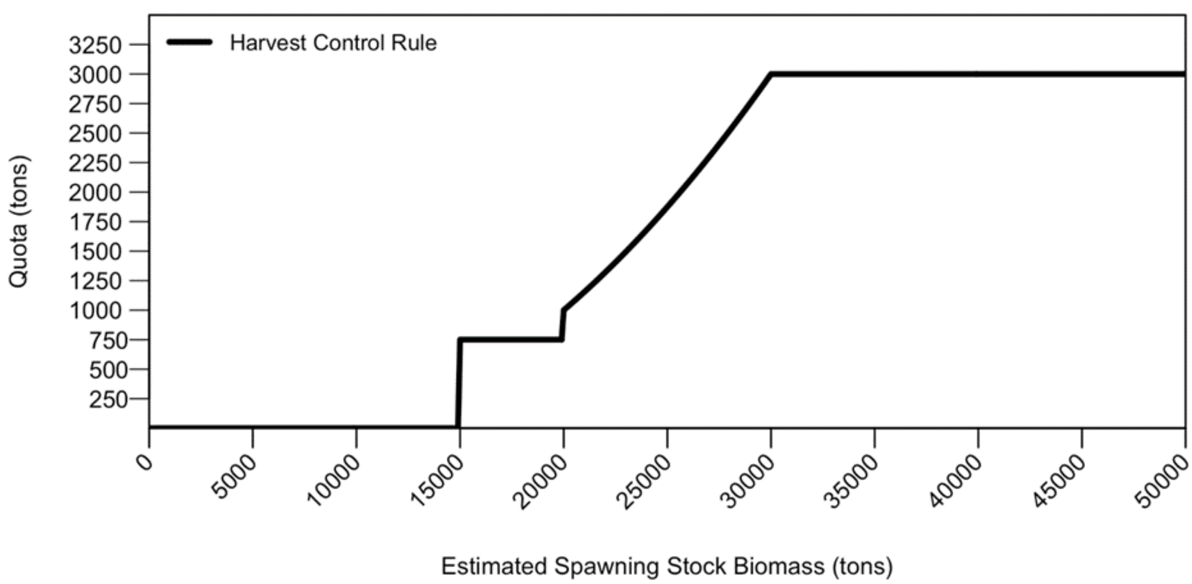

Figure R-1. Preferred Harvest Control Rule.

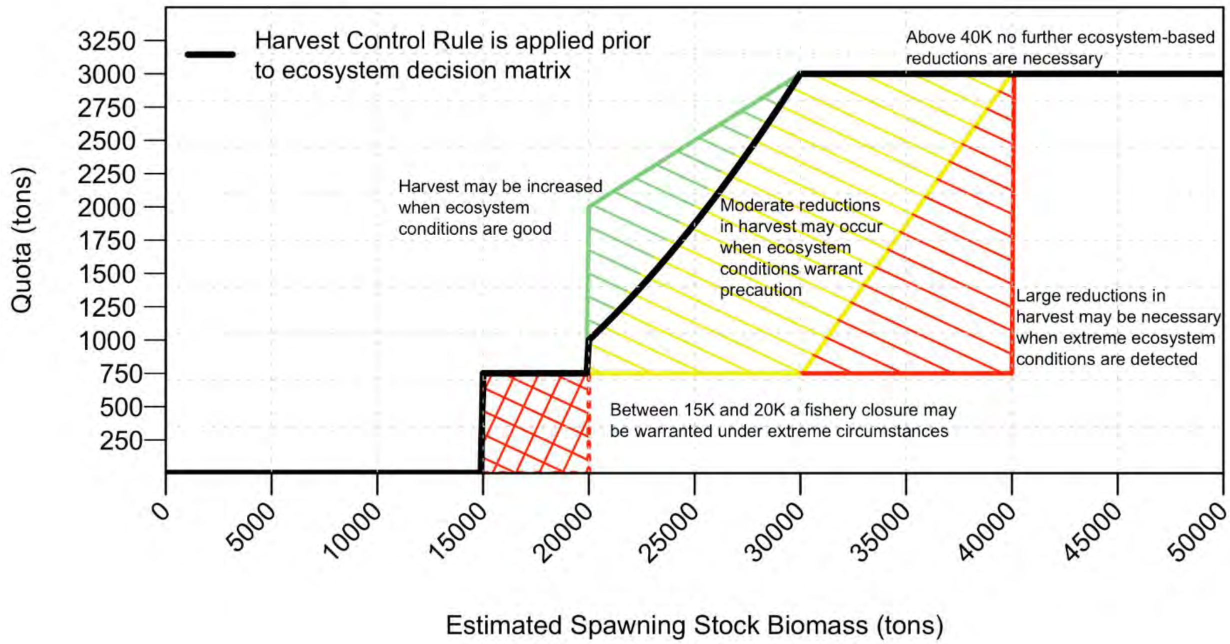

Figure R-2. Initial Harvest Control Rule framework, as proposed by the SC.

The proposed framework utilized a matrix of ecosystem indicators to assist the California Department of Fish and Wildlife (Department) in assessing and, if necessary, adjusting harvest to avoid undue ecosystem impacts based on the information available at the time of quota setting and Department scientists' discretion. This matrix included indicators on the productivity of Herring, the indices of relative variability of forage species in the region, and the population-level health of predators that have been shown to eat Herring. The matrix also provided guidance on how each indicator should be interpreted and recommendations for possible management responses in the event of an increase or decrease for each indicator. However, this matrix provided only qualitative guidance, and left any decisions regarding a change to the quota and how much change was warranted up to the discretion of the Department.

This framework for adjusting quotas was not selected. An independent peer review of the science used to support the FMP was conducted, and the peer review committee had concerns about the use of qualitative guidance; the lack of strong scientific links between indicators, ecological response, and quota adjustment; and the large range of discretion for potential quota adjustments (Appendix O). Their primary concern was that, in the absence of well-defined indicators and thresholds, as well as predetermined rules for how quotas should be adjusted, there was the potential for subjective application of the guidance, which could lead to disagreement between stakeholders and managers about quota decisions each year. The peer review committee also expressed reservations about the use of indicators which had not been tested to determine whether future quota adjustments based on this framework were likely to be aligned with management objectives.

One of the goals in developing the Herring FMP was to incorporate ecosystem considerations into Herring management. In order to develop a transparent, reproducible process for determining when ecological conditions were unusual and additional quota adjustment may be warranted, the Department worked with the Project Management Team to develop the decision tree process described in Section 7.7. In reviewing the available data and studies, Department staff concluded that while there is broad evidence supporting the role of Herring as forage in the central California Current Ecosystem, there is limited evidence for direct links between either the availability of Herring as forage, or the relative variability of various forage indicators, and the health of specific predator populations. As a result, it is not clear that a specific change in quota is likely to have a measurable impact on the health of predator populations except during times of extremely low forage availability. Conversely, additional reductions in quota will have a negative economic impact on the fleet. The preferred HCR sets quotas that are conservative (Appendix M) and the Herring FMP provides many layers of precaution to ensure that Herring can fulfill their ecological role (Section 7.8). For these reasons, the magnitude of ecosystem-based adjustments to the quota were limited to 1% increases or decreases in harvest rate (Figure R-3; see also Section 7.7).

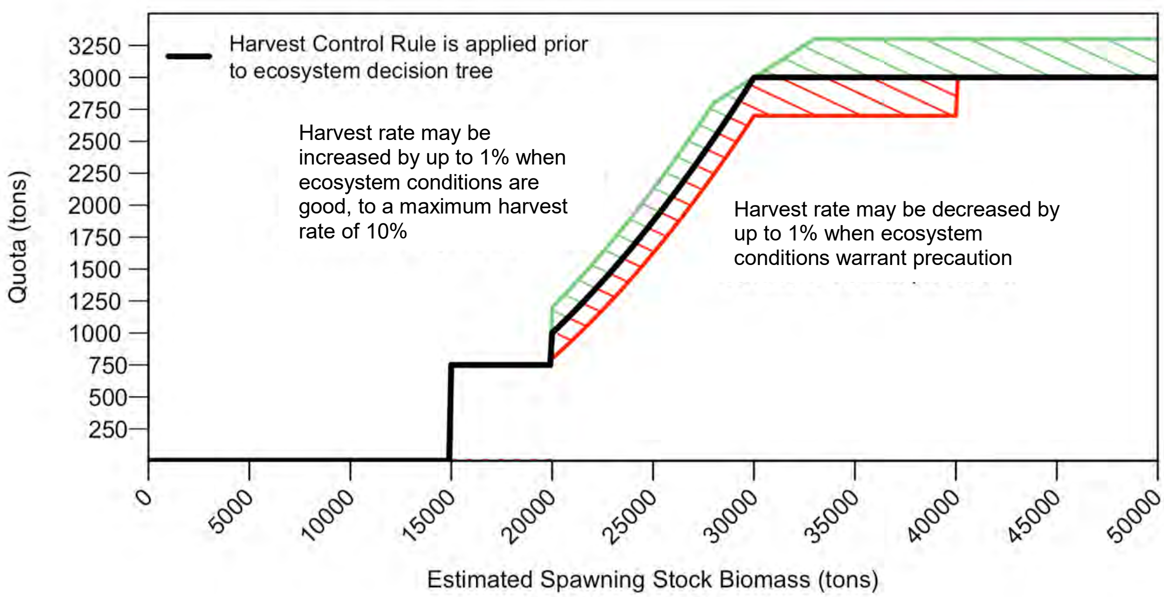

Figure R-3. Final Harvest Control Rule Framework.

Ecosystem-based fisheries management is a growing and continually evolving field. If additional information demonstrating evidence for direct connections between the health of predator populations and the availability of forage species becomes available, the Department may incorporate this information into the decision tree in order to set quotas based on the best available science without amending the FMP (Section 7.7.3 and Section 9.2). This is in line with the California Fish and Game Commission's forage species policy, which seeks to recognize the importance of forage fish to the ecosystem and establishes goals intended to provide adequate protection to these species. Specifically, the Department may incorporate new indicators into the decision tree, as well as alter or remove existing indicators or thresholds, without amendment to the Herring FMP (Section 9.2).

Adding and/or removing indicators should be considered in concert with existing indicators, because all indicators work together to provide a holistic picture of ecosystem conditions. Ideally, the inclusion of any additional indicators should be tested using MSE in order to understand their anticipated performance. The quantitative performance indicators (Appendix M and Section 7.1) should be used to evaluate the impact of the proposed indicators on the Herring stock and the economic viability of the fishery, though other ecosystem-specific performance metrics may also be developed. If it is not possible to conduct a MSE due to resource or capacity constraints, at minimum a retrospective analysis should be conducted to examine how often quotas would have been adjusted in past years under proposed management scenarios, and whether these adjustments align with management objectives.

The Department may also alter the magnitude of quota adjustment, provided these alterations do not exceed the bounds on harvest rate adjustment indicated in the final HCR framework (Figure R-3). Any potential future alteration to the magnitude of ecosystem-based quota adjustments beyond these bounds will require amendment of the Herring FMP.

Implementation of a broader range of ecosystem-based adjustments to a management strategy could be achieved through an FMP amendment (Chapter 9). The peer review committee provided recommendations that can be used to build a transparent, quantitatively based, and tested ecosystem approach to improve the application of ecosystem indicators and the management of the fishery (Appendix O).

Appendix S Public Comments Received, Responses, and Changes to the Draft California Pacific Herring Fishery Management Plan

The Draft California Pacific Herring Fishery Management Plan (Draft Herring FMP) was received by the California Fish and Game Commission (Commission) at their June 2019 meeting. This appendix presents summaries of public comments received by the Commission on the Draft Herring FMP during the public comment period, and California Department of Fish and Wildlife (Department) responses indicating how public comments were addressed (Table S-1). This appendix also summarizes all changes to the Draft Herring FMP (Table S-2). These include corrections to minor errors, as well as changes made in response to public comments received.

Table S-1. Summary of public comments received on the Draft Herring FMP, and Department responses.

Commenter Number	Commenter Name, Organization If Applicable	Draft Herring FMP Section Referenced	Comment Summary	Response
1	Edward Zeng Recreational Participant Email dated 6/18/2019	7.8.7	1-a. The Herring FMP proposes a daily limit of 100 lb. For reasons stated in email (missing spawn windows, health of Herring consumption, low gear requirement for recreational Herring take, low overall recreational catches), Mr. Zeng requests that the daily bag limit be raised to a minimum of 300 lbs.	There are not adequate data available to assess the magnitude of recreational Herring catches, so it is unknown if overall recreational Herring catches are low. The proposed daily limit of 100 lb was chosen to allow for a satisfying recreational experience for individuals while ensuring that total Herring harvest remains sustainable.
2	Hua Bai Recreational Participant Email dated 6/18/2019	7.8.7	2-a. Although a recreational limit is useful to prevent excess take, it is not practical to require recreational participants to have a scale that can weigh 100 lbs., as this requires purchase of extra equipment. An easier rule could be a big cooler full of Herring. Cooler can be sized so it is around 100lb to 200lb. This limit is easy to implement by all parties.	The proposed 100 lb upper limit of the range presented in the Herring FMP is expressed as equivalent to the volume of two 5-gallon buckets. These buckets are commonly owned pieces of equipment that allow participants and enforcement to assess compliance without having to weigh the Herring.
3	Charlie Zhao Recreational Participant Email dated 6/22/2019	7.8.7	3-a. Because recreational take depends on targeting an ongoing spawning event, this type of fishing is typically a once-per-year opportunity. Mr. Zhao typically tries to take an entire year's worth of fish in a single trip (roughly equal to two 27-gal containers from Costco, for one-gallon zip lock bag consumption daily for family all year). Even if people are commercializing recreational catch illegally, it does not affect ability of other recreational fishers to catch what they need. Mr. Zhao believes Herring are abundant, and that the commercial fishery takes much more, and has greater impact on population, than recreational take. There should not be a limit on rec take, and if there must be one, it should be set in	The proposed range of possession limits presented in the Herring FMP specifies both weight and volume of fish for ease of use by both participants and enforcement. This proposed limit is in line with the Department's goal of maintaining a satisfying recreational experience for participants. Recreational fishing limits are not intended to supply participants with a daily food source throughout the year.

			volume for ease of measurement in field. Proposes 50 gallons as a reasonable limit if we must have one.	
3	Charlie Zhao (Continued)	7.8.7	3-b. Setting a recreational limit on Herring disproportionately affects minorities because of much higher consumption of Herring among certain minority groups. As health care becomes more and more expensive and drags on the economy, Herring consumption should be encouraged instead of limited.	The Department is responsible for protecting the long-term sustainability of the Herring resource, to the extent possible, and to ensure that all of California's recreational participants can benefit from this resource for many years to come.
4	Alastair Bland Recreational Participant Email dated 7/4/2019	7.8.7	4-a. Concerned about proposal to limit recreational participants to two 5-gallon buckets or less per day. Four 5-gallon bucket (~150 lb) would be more reasonable than two buckets. A four-bucket limit would eliminate gross overtake, would remove incentive to illegally sell recreationally caught fish, would allow recreational participants to catch all that's needed for a year (share w/ family and friends) during a single spawn event. The Herring FMP's claim that recreational stakeholders expressed interest in 2-bucket limit misconstrues context of statement at 2018 Public Outreach meeting w/ stakeholders in Sausalito. Mr. Bland finds it personally offensive that commercial participants have called for tight limits on recreational catch, given that commercial fishery takes a far greater amount of Herring and sells for non-consumptive use, than recreational participants, who mostly eat their catch.	The proposed limit allows recreational participants to take up to 100 pounds (approximately 520 fish) per person per day. Families that would like to retain a greater number of fish are able to have more people participate in fishing. All comments at the 2018 Sausalito meeting were recorded in order to accurately capture stakeholder feedback.
4	Alastair Bland Second email dated 7/5/2019	7.8.7	4-b. Second comment letter further stressing that the Herring FMP's assertion that feedback from recreational sector informed proposed limit is essentially an overstatement.	Stakeholder feedback is an important part of the Herring FMP development process. All comments at the 2018 Sausalito meeting were recorded in order to accurately capture stakeholder feedback. Stakeholder support for the Department's proposed limit was expressed at this meeting and in follow up correspondence, in addition to some feedback that that the limit should be higher.
5	John Vogel	7.8.7	5-a. The proposed limit for recreational Herring harvest is too low. Recreational Herring is a unique fishery with opportunity to catch only	The proposed upper limit for recreational take would allow participants to take up to 100 pounds (approximately 520 fish) per person.

	Recreational Participant Email dated 7/23/2019		once or twice a year. He understands the need to prevent over harvest, but is not aware of a significant number of recreational participants harvesting huge quantities for illicit commercialization or waste. Wants a five 5-gallon buckets as a limit.	Families that would like to maximize the amount of fish they take legally may choose to have more family members participate in fishing. While the Department understands that, due to the pulse nature of spawning events, there may be limited fishing opportunities in a season, this limit is designed to balance providing a satisfying recreational experience with the needs of the resource.
6	Kirk Lombard Recreational Participant, Blogger and Author, Fishmonger Email dated 7/24/2019	7.8.7	6-a. The proposed recreational limit range goes too far. Supports limits in general. A zero-bucket limit is an overreaction. Makes six points about recreational take of Herring, including limited number of days they are accessible from shore, and that most people only take a few buckets during spawns (problem of over harvest stems from a few bad apples). Mr. Lombard contrasts recreational take with commercial gillnet take (recreationally-caught fish are eaten locally, gillnet catch is exported) emphasizing local benefit of recreational take and poor quality of gillnet-acquired fish for eating. He points out high utilization by Asian Americans and high level of complaint from non-Asian Americans and commercial fishermen. Mr. Lombard suggests that one bucket only seems like a large quantity to individuals who do not fish for Herring, since a single bucket only lasts 3 months, and emphasizes the healthy aspects of eating low-on-the-food chain species caught locally.	While the Department understands that Herring are only available during a few nearshore spawning events, those events can experience intensive recreational pressure, with hundreds of participants targeting Herring. The proposed limit is designed to allow participants a satisfying recreational experience while limiting the impacts of harvest on the schools that spawn in these nearshore areas.
6	Kirk Lombard (Continued)	7.8.7	6-b. Prefers for the lower end of recreational Herring limit range be two 5-gallon buckets, if not 3-4.	The 0-lb lower limit to the Herring FMP's recommended range allows for closure of the recreational fishery without an amendment should conditions in the future require such a closure.
7	Russell Johnston Marine Science Institute, UC	General	7-a. General support for adoption pending specific listed changes.	The Department appreciates support for the Herring FMP. It has responded to comments received as appropriate.

	Santa Barbara Email dated 7/25/2019			
7	Russell Johnston (Continued)	Appendices	7-b. Provide all appendices as part of FMP and organize so as to be readily navigated by the public.	Appropriate page numbering has been applied and all appendices are included in in the Final Herring FMP. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.
7	Russell Johnston (Continued)	2.13.2.3, Appendix D	7-c. Include Humboldt Bay spawn areas in maps of spawn areas depicted in Chapter 2 and Appendix D.	Habitat maps for management areas where no commercial activity occurs at the time of Herring FMP development are presented in Appendix D. However, the Humboldt Bay map in the Draft Herring FMP Appendix D did not include spawn areas. Detailed maps of recent observed spawning locations are available for Humboldt Bay and have been be included in the Final Herring FMP. Section 2.13.2.3 has been edited to refer the reader to Appendix D for Humboldt Bay spawn areas.
7	Russell Johnston (Continued)	Executive Summary, General	7-d. Present all FMP goals equally, including compliance with forage species policy and incorporation of ecosystem indicators.	The primary management goals outlined in the Herring FMP are those described in the MLMA, which provides the legal framework for fisheries management in California. For this reason, these goals are given primacy in the Herring FMP. However, the Commission's forage species policy also played an important role in the development of the FMP objectives, as described in the Herring FMP.
8	Nick Sohrakoff Commercial Participant, Director's Herring Advisory Committee President, FMP Steering	4.7.2	8-a. The SFBHRA (San Francisco Bay Herring Research Association) did not file a lawsuit. The lawsuit in referenced was filed by the SFHA (San Francisco Herring Association). Please correct the draft changing SFBHRA to SFHA to reflect the proper entity that filed the lawsuit.	This error has been corrected in the Final Herring FMP.

	Committee Member Email dated 7/29/2019			
8	Nick Sohrakoff Oral Comment w/ Anna W. (Commenter 10) at FGC Meeting 8/8/2019	General	8-b. General expression of support – DHAC supported FMP 12 years ago, SC was a successful collaborative effort, would like to fund a genetic study with Audubon for stocks in CA and southern Oregon.	The Herring FMP was the result of a great deal of work by many different stakeholders, and the Department hopes to continue future collaborations to benefit the resource.
9	Geoff Shester, Oceana and FMP Steering Committee; Anna Weinstein, Audubon California and FMP Steering Committee; Irene Gutierrez, NRDC; Greg Helms, Ocean Conservancy; Andrea Treece, Earthjustice; Paul Shively, Pew	Appendices	9-a. Appendix R is currently missing from the FMP due to an error. Based on an agreement by the Steering Committee, this Appendix was intended to describe an increased range of catch limit adjustments resulting from ecosystem considerations that the Department may use as scientific information improves, without an FMP amendment. We request that Appendix R be included in the FMP and that the public be afforded the opportunity to review and provide comments on its contents prior to final adoption of the FMP.	Appendix R was drafted, but omitted from the Draft Herring FMP in error. Appendix R was included in an updated Draft FMP that was made available for public viewing and comment, and is included in the Final Herring FMP. Appendix R contains information on the development of the Harvest Control Rule framework, as well as guidance for amending the decision tree as the field of ecosystem-based fishery management develops. Any increase in the bounds on ecosystem-based quota adjustment beyond those indicated in Chapter 7 (Figure 7-3) and Appendix R (Figure R-3) will require an amendment.

	Charitable Trusts Letter dated 7/25/2019 (NGO Letter)			
9	NGO Letter (Continued)	7.5.3	9-b. We request the FMP include clear, objective criteria for determining whether a Tier 2 stock is overfished and clarify what the rebuilding provisions are for overfished Tier 2 stocks. The MLMA requires that FMPs must specify criteria for identifying when a stock is overfished, include measures to end or prevent overfishing, and provide a mechanism for rebuilding in the shortest time period possible (FGC §7086). While the draft FMP identifies criteria for determining whether the San Francisco Bay stock is overfished as well as rebuilding provisions (Section 7.8.1), it does not contain criteria for determining whether any of the stocks outside San Francisco Bay stocks would be considered overfished when they are in Tier 2. It also does not specify how the San Francisco Bay stock would be considered overfished if it is moved to Tier 2 status in the future. The FMP does not provide objective criteria for what constitutes "very poor spawning behavior" or "an SSB too small to support fishing." For example, this could be remedied by clarifying how "low" or "very poor spawning behavior" is determined in the Rapid Spawn Assessments for Tier 2 stocks and stating in the FMP that this is the criteria for overfished.	Section 7.5.3 has been amended in the Final Herring FMP to include specific criteria for determining when a given management area's spawning stock biomass is considered overfished or otherwise depressed under Tier 2. If the stocks drop below these respective limits, the quotas will be set to zero to promote stock rebuilding. This brings the management plan into compliance with the MLMA, which states that FMPs must specify overfishing limits and rebuilding plans.
9	NGO Letter (Continued)	Appendices	9-c. The number and size of the Appendices substantially increase the size of the overall FMP document, which as presented, will complicate navigation of the FMP by the public. While each Appendix provides important information and is referenced in the body of the FMP, we suggest the Appendices be available as separate	Appropriate page numbering has been applied to all appendices in the Final Herring FMP. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.

			documents from the main body of the FMP, and that each Appendix contain consistent page numbering and formatting to improve navigation of the FMP.	
9	NGO Letter (Continued)	General	9-d. Throughout the document, the term "quota" is used when referring to the annual catch limit. The term quota is problematic because in other contexts "quota" may refer to a minimum quantity or goal, rather than a maximum limit. To maintain consistency and clarity for the public, we request the FMP not use the term "quota" and instead use the term "catch limit."	The term "quota" is frequently used interchangeably with "catch limit" in fisheries management. In addition, the Marine Life Management Act uses the term "quota" rather than "catch limit" in specifying the types of conservation and management measures that should be described in an FMP (Section 7802(c)). Furthermore, the term quota has been used historically in documents related to management of California's Pacific Herring fishery. For consistency with these documents, the Final FMP retains use of the word "quota".
9	NGO Letter (Continued)	2.13.2.2, Appendix D	9-e. In Section 2.13.2.3 (p. 2-26), the Department's maps of Herring spawning areal extent and most-used spawning areas for Humboldt Bay should be included, in the manner San Francisco Bay's maps appear in that section. Also, these updated maps should be put into the Habitat section (pg. 319).	Habitat maps for management areas where no commercial activity occurs at the time of FMP development are presented in Appendix D. However, the Humboldt Bay map in the Draft FMP Appendix D did not include spawn areas. Detailed maps of recent observed spawning locations are available for Humboldt Bay and have been be included in the Final FMP. Section 2.13.2.3 has been edited to refer the reader to Appendix D for Humboldt Bay spawn areas.
9	NGO Letter (Continued)	7.7.2	9-f. The Executive Summary (p. ii) and Section 7.7.2 state that complying with the Commission's Forage Species policy is a secondary goal. This prioritization undercuts the Commission's forage policy and implies that other goals are more important. We request that the FMP present all goals equally, including compliance with the Forage Species policy and incorporating ecosystem considerations into Herring management.	The primary management goals as outlined in the Herring FMP are those described in the MLMA, which is the overarching legal framework for fisheries management in California. For this reason, these goals are given primacy in the Herring FMP. However, the Commission's forage species policy played an important role in the development of FMP objectives, as described in the Herring FMP.
9	NGO Letter (Continued)	Executive Summary, 7.6.3	9-g. The Executive Summary (p. iv) indicates that the multi-indicator predictive model is adopted by the FMP. However, Section 7.6.3 makes clear	The Herring FMP adopts the multi-indicator predictive model as an option for estimating Spawning Stock Biomass in the San Francisco

			that the spawn deposition surveys are the default for estimating San Francisco Bay SSB until the predictive model has 3 or more years of successful predictive power. The Executive Summary should be clarified consistent with this description in Section 7.6.3.	Bay management area. The Final Herring FMP Section 7.6.3 has been edited to clarify the requirements for use of the multi-indicator predictive model. Spawn deposition surveys remain the default method for determining Spawning Stock Biomass, and the Executive Summary has been edited to clarify this.
9	NGO Letter (Continued)	7.7.1, Figure 7-2; Appendix F	9-h. The FMP should clarify that Figure 7-2 represents the default harvest control rule, which is subject to ecosystem adjustments as indicated by the decision tree. Currently, Appendix F and Figure 7-2 are misleading because they do not reference potential adjustments to catch limits based on ecosystem considerations, therefore implying that these represent the final catch limit.	Chapter 7 has been modified so that the caption for Figure 7-2 clarifies that the black line indicates the unadjusted quota for the season. Section 7.7 describes how the quota may be adjusted for ecosystem considerations.
9	NGO Letter (Continued)	Executive Summary	9-i. Given California's leading role in addressing the climate crisis, the Executive Summary should emphasize and highlight the several areas where climate change is addressed in the FMP, specifically the use of climate indicators in the predictive model, the use of management strategy evaluation to ensure the harvest control rule is robust to future climate change scenarios, and the use of climate indicators as ecosystem considerations.	Adaptive management frameworks based on the best available science and including multiple indicators, such as the framework presented in the Herring FMP, are key tools for promoting climate change resilience in fisheries management, and this is emphasized throughout the document. The Executive Summary has been updated in the Final Herring FMP to better reflect this.
9	NGO Letter (Continued)	Acknowledge-ments	9-j. Finally, we request that the Acknowledgments section recognize all cash funding sources for the FMP, specifically the Gordon and Betty Moore Foundation and the National Fish and Wildlife Foundation.	The Gordon and Betty Moore Foundation has been added to the Acknowledgements in the Final Herring FMP.
9	NGO Letter (Continued)	General	9-k. For the [several stated] reasons, we support the adoption of the FMP. We request the Commission incorporate the above recommendations on the Draft Herring FMP into the final version and urge the Commission to adopt the Final Herring FMP at its October meeting, as scheduled.	Support for the Herring FMP is appreciated. Comments received have been responded to here and in the Final FMP as appropriate.

10	Anna Weinstein Audubon California Herring FMP Steering Committee +3,258 Individual Signatories Letter dated 7/31/2019	General	10-a. [Signatories and Audubon] support the adoption of the Fishery Management Plan (FMP) for Pacific Herring at your meeting in October 2019, pending specific changes listed.	Support for the Herring FMP is appreciated. Comments received have been responded to here and in the Final FMP as appropriate.
10	Anna Weinstein +3,258 Individual Signatories (Continued)	Appendices	10-b. All the Appendices are provided as part of the FMP and organized so they can be readily navigated by the public.	All appendices, including Appendix R (see response to Comment 9-a), are now available for the public to review, and include appropriate page numbering. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.
10	Anna Weinstein +3,258 Individual Signatories (Continued)	2.13.2.3, Appendix D	10-c. The Department's maps of Herring spawning areal extent and most-used spawning areas for Humboldt Bay should be included in the FMP.	Habitat maps for management areas where no commercial activity occurs at the time of Herring FMP development are presented in Appendix D. However, the Humboldt Bay map in the Draft Herring FMP Appendix D did not include spawn areas. Detailed maps of recent observed spawning locations are available for Humboldt Bay and have been be included in the Final FMP. Section 2.13.2.3 has been edited to refer the reader to Appendix D for Humboldt Bay spawn areas.
10	Anna Weinstein +3,258 Individual Signatories	Executive Summary	10-d. In the Executive Summary and throughout the FMP, present all FMP goals equally, including compliance with the forage species policy and incorporating ecosystem considerations into Herring management.	The primary management goals as outlined in the FMP are those described in the MLMA, which is the overarching legal framework for fisheries management in California. For this reason, these goals are given primacy in the Herring FMP. However, the Commission's forage species

	(Continued)			policy played an important role in the development of the FMP objectives, as described in the FMP.
10	Anna Weinstein Oral comment w/ Nick S. (Commenter 8) at FGC meeting 8/8/2019	General	10-e. General support. Commend and thank involved parties, including FGC. FMP is groundbreaking.	Support for the Herring FMP is appreciated.
10	Anna Weinstein Oral comment w/ Nick S. (Continued)	General	10-f. Audubon has provided comment and non-substantive requests to ensure transparency and MLMA compliance (formatting fixes, better assembled appendices on website, tier 2 fishery criteria).	Comments received have been responded to here and in the Final FMP as appropriate.
11	Nils Warnock Audubon Canyon Ranch (ACR) Letter dated 7/31/2019	7.8.2.2	11-a. ACR agrees with the Commission's recommendation to reduce the maximum number of permits allowed for Tomales Bay (from 35 to 15 via attrition), but further recommends that no new permits be issued for Tomales Bay (instead of beginning to issue once number of Tomales permits drops below 15). Rather, Tomales Bay would be best left as a protected area for Herring. Cites linked importance of Herring to seabirds, lack of commercial interest in Tomales Bay Fishery, and proximity to SF bay fishery as reasons.	The FMP specifies a management approach for Pacific Herring in Tomales Bay that is compatible with both conservation and fishing goals. Should there be renewed commercial interest in Herring fishing in Tomales Bay, the quota will be set at a small fraction of historical quotas to ensure that the Tomales Bay Herring stock can serve as food for predators as well as support a small commercial fishery, as described in Chapter 7.
11	Nils Warnock (Continued)	7.8.7	11-b. ACR endorses FMP's recommendation of a recreational bag limit range of 0-100 lbs, equivalent to up to ten gallons, or two 5-gallon buckets of Herring, each containing 260 fish.	Support for the Herring FMP's recreational bag limit is appreciated.

11	Nils Warnock (Continued)	Chapter 7 - Tomales Bay Spawning Biomass Surveys	11-c. As current monitoring data are critical for helping managers steward resources, especially during these times of rapid climate change, ACR encourages the Commission to recommend renewed Herring monitoring in Tomales Bay.	The Herring FMP identifies management areas with active commercial fisheries as the highest priority for monitoring. As described in Chapter 7, an appropriate level of monitoring will resume in Tomales Bay should commercial fishing activity resume there.
11	Nils Warnock (Continued)	General	11-d. With some suggested modifications, Herring FMP will provide strong guidance for the long-term sustainable mgmt. of Pacific Herring in California, including Tomales Bay.	Support for the Herring FMP is appreciated. Comments received have been responded to here and in the Final FMP as appropriate.
12	Pam Young Golden Gate Audubon Society Letter dated 7/31/2019	General	12-a. General support for the Herring FMP, including use of the best available science to support sustainable management.	Support for the Herring FMP is appreciated.
13	Morgan Patton, West Marin Environmental Action Committee (EAC); Ashley Eagle-Gibbs, EAC Letter dated 8/1/2019	7.8.7	13-a. Consistent with past comments and Audubon Canyon Ranch's comments, EAC supports the Herring FMP's daily bag limit two 5-gallon buckets of Pacific Herring	Support for the Herring FMP's recreational bag limit is appreciated.
13	Morgan Patton, Ashley Eagle Gibbs (Continued)	Chapter 7, General	13-b. While supportive of the overall management strategy in Chapter 7 of the Herring FMP, recommend full closure of commercial fishery in Tomales Bay, due to a number of factors. These include low Herring numbers, environmental considerations, lack of interest, high operating costs, and poor market	Support for the Herring FMP's management strategy is appreciated. The Herring FMP specifies a management approach for Pacific Herring in Tomales Bay that is compatible with both conservation and fishing goals. As described in Chapter 7, a precautionary quota is available, and an appropriate level of

			conditions. No recent research (other than observations) has been conducted to indicate adequate biomass for the Tomales Bay fishery operation. Recommend CDFW (or other qualified and independent researchers) conduct renewed monitoring of Herring populations in Tomales Bay in order to compare against outdated information that is now 13 years old [limited monitoring conducted during 2006-07 season] to better understand the population dynamics	monitoring shall occur should commercial interest in the Tomales Bay stock resume.
13	Morgan Patton, Ashley Eagle Gibbs (Continued)	Chapter 7, General	13-c. The Tomales Bay Herring fishery should only be open after a comprehensive and scientifically based assessment and analysis is made of the Herring stocks, current and future spawning estimates, biomass, etc. led by Department of Fish and Wildlife staff and/or other trained and independent researchers, with the involvement of multiple stakeholders. EAC requests that these opportunities are truly collaborative and include stakeholders representative of multiple interests including local West Marin fisherman, individuals from non-extractive industries, and environmental organizations.	Should there be renewed commercial interest in Herring fishing in Tomales Bay, the Herring FMP specifies that the quota will be set at precautionary harvest rate to ensure that the Tomales Bay Herring stock can fulfill its ecological role as forage for predators as well as support a small fishery. This harvest rate can only be increased with additional monitoring demonstrating the population can support additional harvest, including determination of the Spawning Stock Biomass. The Department welcomes the opportunity to collaborate with stakeholders to increase our collective understanding of California's Pacific Herring stocks.
14	Julie Thayer, Ph.D. Farallon Institute Letter dated 7/31/2019 in attachment to Email dated 8/1/2019	Chapters 3, 7; Appendices E, F	14-a. Work conducted by the Farallon institute as a contractor on FMP development was not accurately represented in the draft FMP. Includes specific description of issues with information presented in Ch 3, Ch 7, and Appendix E, and F. Inaccurate representation of this work led to erroneous conclusions by Peer Review of FMP science. Requests that actual contractor work be presented in the appendices.	The Farallon Institute was subcontracted to assist the Project Management Team with developing scientific advice for the management of Pacific Herring. This work produced a number of valuable contributions to the field of ecosystem-based fishery management, and the parts that were used in the development of the FMP's management framework were provided to the Peer Review, are reproduced in Appendices E and F. However, there were other components of the work produced that were evaluated by the Project Management Team, the Department, and the Steering Committee that were deemed to be not suitable for use in the management framework at this time. The Peer

				Review committee requested to see, and were provided, additional components from the Farallon Institute's work that were not used in the Herring FMP during the review process. As such, the review committee's final recommendation does take into account these additional components as well.
14	Julie Thayer, Ph.D. (Continued)	Chapter 7, 7.6.3	14-b. Chapter 7 incorrectly states that the predictive model needs to be tested before use, though it has already been validated against 27 years of SF Bay biomass.	The Herring FMP adopts the multi-indicator predicted model as an option for estimating Spawning Stock Biomass in the San Francisco Bay management area. The Final Herring FMP Section 7.6.3 has been edited to clarify the requirements for use of the multi-indicator predictive model. Specifically, the model's use depends on availability of required data and its continued predictive skill.
14	Julie Thayer, Ph.D. (Continued)	Appendix E	14-c. Appendix E summarizes a draft report of the SSB forecasting model submitted by Farallon Institute early in the FMP development process, instead of the final publication of this work which included key revisions to the original draft	The information summarized in appendices E and F includes the portions of the work produced by the Farallon Institute under subcontract by the Project Management Team that were included in the Herring FMP. The final publication referred to (Sydeman and others, 2018) does not include the multi-indicator predictive model adopted by the Herring FMP. However, this publication is referenced in the FMP, including in Appendix E, as appropriate.
14	Julie Thayer, Ph.D. (Continued)	Chapter 9, Appendix R	14-d. Considerations for future research and management should include the importance of making ecosystem-based catch adjustments more meaningful. Re-instate appendix R, allow wider discretion on quota adjustment bounds in HCR framework.	Appendix R was drafted, but omitted from the May-dated Draft FMP in error (see response to Comment 9-a). It has been included in the Final FMP and contains information on the development of the Harvest Control Rule framework, as well as guidance for amending the Decision Tree as the field of ecosystem-based fishery management develops. Any increase in the bounds on ecosystem-based quota adjustment beyond those indicated in Chapter 7 (Figure 7-3) and Appendix R (Figure R-3) will require FMP amendment.

14	Julie Thayer, Ph.D. (Continued)	2.4, 5.6, Chapter 8	14-e. Importance of temporal variability in spawning should be explicitly stated in the FMP (w/ specific recommendations for Sections 2.4, 5.6, and Chapter 8).	The observed temporal variability in Herring spawning is stated a number of times throughout the Herring FMP. In particular, Section 2.4 and Figure 2-4 describe the available information on this variability. Section 8.6 also flags changes in observed spawning habitat over time as a key uncertainty and avenue for future research.
14	Julie Thayer, Ph.D. (Continued)	Appendices	14-f. The FMP is prohibitively large and difficult to navigate due to myriad of appendices, both current and historical information. Suggest final document only include immediately-relevant supplemental material such as formulas and decision trees, w/ clear page numbering. Historical info should be separated into distinct files that can be downloaded separately, and are also clearly referenced.	California's Herring fishery is complex, with a long history of management. The FMP serves as a central repository for all of the available information on Pacific Herring and its management in California. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.
15	Jennifer Fearing Fearless Advocacy Oral comment at FGC meeting 8/8/2019	General	15-a. Strong support for adoption in October. The FMP is a tremendous step forward for Ecosystem-Based Management. Appreciate CDFW incorporating appendix R	Support for the Herring FMP is appreciated. Appendix R was drafted but was omitted in error (see response to Comment 9-a). It has been included in an updated draft of the FMP and is available for review.
15	Jennifer Fearing (Continued)	7.5.3	15-b. As per NGO Letter (see Commenter 9), recommendations to strengthen MLMA compliance w/out altering timeline for adoption, request Fish and Game Commission direct CDFW to address those recommendations prior to adoption.	Section 7.5.3 has been amended in the Final Herring FMP to include criteria for determining when a given management area's spawning stock biomass is considered overfished or otherwise depressed under Tier 2. If the stocks drops below these limits, the quotas will be set to zero to promote stock rebuilding. This brings the management plan into compliance with the MLMA, which states that FMPs must specify overfishing limits and rebuilding plans.

Table S-2. Summary of minor corrections and changes to the Draft Herring FMP.

Document Section	Page Number	Correction
Title page	*NA*	~~Draft~~ California Pacific Herring Fishery Management Plan ~~Draft~~ ~~August 08, 2019~~ October, 2019
Executive Summary	ii	The overarching goal of this FMP is to ensure the long-term sustainable management of the Herring resource consistent with the requirements of the Marine Life Management Act (MLMA) and the Commission's forage species policy. In particular, it seeks to: (…) • describe the effects of climate change on California's Herring stocks, and identify environmental and ecosystem indicators that can inform effective management,
Executive Summary	iv	~~The currently used method is available as a backup should data be unavailable or should environmental changes compromise the predictive power of the model.~~ The FMP adopts this multi-indicator predictive model as an option for estimating the coming year's SSB in the San Francisco Bay management area, contingent upon availability of necessary input data and continued predictive power by the model. Spawn deposition surveys remain the default method for determining SSB.
Acknowledgements	xxii	Finally, the Gordon and Betty Moore Foundation and the National Fish and Wildlife Foundation provided the necessary funding to support the Project Management Team, composed of Dr. Sarah Valencia, Huff McGonigal, and David Crabbe.
2.8, Figure 2-5 caption	2-10	Figure 2-5. ~~Observed age distribution of the research catch in San Francisco Bay,~~ Percent at age, by number, of ripe fish for the San Francisco Bay spawning stock

		biomass. Based on age composition of the research catch (excluding age-1 fish), 1982-83 through 2017-18 seasons. Note that no sampling was conducted in final age composition was not determined for the 1990-91 and 2002-03 seasons.
2.8	2-10	…the North Pacific Marine Heatwave (Chapter Section 3.2).
2.13.2.3	2-26	Herring spawning occurs in both North and South Bays, although North Bay typically receives the majority of spawning activity. Spawning has occurred every year in North Bay since the fishery began during the 1973-74 season. Maximum spawning extents observed during the 2014-15 through 2017-18 seasons are presented in Appendix D.
4.2, Figure 4-2 caption	4-3	California Herring landings by area in short tons between 1973 and 2017 in San Francisco Bay (blue), Tomales Bay (yellow), Humboldt Bay (gray), and Crescent City Harbor (black). The commercial fishery was closed for the 2009-10 season. Note that this figure does not include landings from the ocean waters fishery (Monterey Bay).
4.7.2	4-16	In 2014, the SFBHRA San Francisco Herring Association, a group of commercial Herring fishermen, filed a lawsuit against Pacific Gas and Electric (PG&E) for contamination of the San Francisco Bay waterfront.
4.7.3, Table 4-2 caption	4-18	2017 Commercial landings and ex-vessel value for the five most valuable fisheries each in the San Francisco, Tomales, Eureka, and Crescent City ports in 2017.
5.6.1, Table 5-2 caption	5-12	Table 5-2. California Herring fishery season dates prior to the implementation of this FMP.
5.6.2.2	5-13	Currently, Herring offloading only takes place at Pier 45 on the San Francisco waterfront. *Remove sentence as unnecessary and potentially inaccurate in the future. Section is titled "Nighttime Restrictions on Unloading", and content functions just fine without this sentence.*
6.2.1	6-12	Spawn surveys in Tomales and Humboldt Bays were discontinued after 2006-07 due to staffing and resource constraints. Due to low Herring roe prices and lack of processing facilities, at the time of FMP development, no commercial fishing has occurred…
7.4	7-6	The Tier 1 quota for Crescent City Harbor is set at 12 11 tons (1110 metric tons), which is 50% of the average historical landings and a 60%63% decrease from the quota prior to the adoption of this FMP.
7.5.3	7-8	Conversely, under a Tier 2 monitoring protocol, the quota shall be reduced to zero as a rebuilding provision in years where either the employed Rapid Spawn Assessment indicates poor spawning behavior, or spawn deposition survey-derived SSB estimates

		indicate an SSB too small to support fishing that is overfished or otherwise depressed. For San Francisco Bay, the stock is considered overfished or otherwise depressed at SSB estimates below the 15,000-ton cutoff established by the HCR (see Section 7.7.1). For Tomales Bay and Humboldt Bay, the stock is considered overfished or otherwise depressed at stock sizes that are less than 20% of the long-term average biomass (including historical and contemporary SSB estimates) for each respective management area. For Crescent City Harbor, the stock is considered overfished or otherwise depressed at SSB estimates less than 66 tons, which is approximately three times the average historical catch in that management area.
7.6.2.1	7-10	All necessary data are may be available by the end of September each year, and prior to the beginning of the fishing season, which begins in December.
7.6.3	7-12	While the predictive model provides a promising avenue for incorporating additional indicators into Herring management, as well as for improving predictive accuracy, the model needs to be tested before it is used to set quotas. To do this, the model must have three consecutive years where a) all of the data required are available, and b) demonstrate that over those three years it has greater predictive skill than the spawn deposition survey alone. At that point the model's use depends on availability of required data and the model's continued predictive skill (see Section 7.6.2.1, Appendix E). When these two requirements are met, the Department may decide to use the predictive model in yearly quota setting.
7.7.1, Figure 7-2 caption	7-13	HCR Harvest Control Rule describing the relationship between estimated SSB and unadjusted quota for subsequent season of the San Francisco Bay Herring commercial fishery.
7.7.2.3	7-21	Should one or more of the criteria in the decision tree recommend that the Department consider reducing the quota, a 300 ton (272 metric ton) reduction in the harvest should be applied the target harvest rate may be reduced by up to 1% (Figure 7-3).
7.7.2.3	7-22	Conversely, if an increase is warranted, a 300 ton increase to the quota should be applied the target harvest rate may be increased by up to 1% (Figure 7-3).
9.2	9-4	Additionally, as the science evolves, the Department may adjust the magnitude of changes to the quota recommended by the decision tree up to the limits defined in Appendix R Section 7.7.2.3, provided the supporting science is clearly documented (see Appendix R).

All appendices	*multiple*	*Insert incomplete and/or missing page numbers into all pages of all appendices*
Appendix D, Figure D3 and caption	D-3	*Include recent ('14-'15 thru '17-'18 seasons) spawn areas in Humboldt Bay map;* Figure D3. Eelgrass and other habitat types in Humboldt Bay (from Schlosser and Eicher, 2012) and Herring spawn coverage.
Appendix D, Figure D6	D-6	*Include Noyo Harbor eelgrass map; update figure numbers in appendix.*
Appendix E	E-7	Based on these criteria, ~~the model that provided the best prediction for the current year SSB included three factors: SSB_{yr-1}, YOY_{yr-3} and $SST_{(Jul-Sep)\ yr-1}$ (Table E-3 and Figure E-3). Notably, current Department fishing quotas are based on SSB_{yr-1}. T~~ the three-factor models~~, including the current model used by the Department~~ out-performed simpler one- and two-factor models by a large margin (improved r2 = 0.64-0.67 compared to 0.31 to 0.58; improved model fit AIC = 188 to 190 compared to 193 to 204, and reduced predictive error of 63% to ~~64~~69% compared to 77% to 119%) (Sydeman and others, 2018; Table E-3). The three-factor model that provided the best prediction for the current year SSB included: SSB_{yr-1}, YOY_{yr-3} and $SST_{(Jul-Sep)\ yr-1}$. Notably, current Department fishing quotas are based on SSB_{yr-1}.
Appendix R	*multiple*	*Included Appendix R in response to public comment (see Table S-1).*
Appendix S	*multiple*	*Add Appendix S, including summary of public comments received and responses (Table S-1), and summary of changes to the FMP (Table S-2).*
Chapter 11. Works Cited	11-10	Merkel & Associates. 2016. Noyo River and Harbor Maintenance Dredging Pre-dredge Eelgrass Survey Results Transmittal. Prepared for U.S. Army Corps of Engineers San Francisco District, September 2016.
All	*multiple*	*Various corrections to capitalization, spacing, spelling, punctuation, font, nomenclature, and formatting.*

Chapter 11. Literature Cited and References

Ainley DG, Boekelheide RJ. 1990. Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-System Community: Stanford University Press. 488 p.

Ainley DG, Spear LB, Allen SG, Ribic CA. 1996. Temporal and Spatial Patterns in the Diet of the Common Murre in California Waters. The Condor 98(4):691-705.

Alderdice DF, Hourston AS. 1985. Factors Influencing Development and Survival of Pacific Herring (*Clupea harengus pallasi*) Eggs and Larvae to Beginning of Exogenous Feeding. Canadian Journal of Fisheries and Aquatic Sciences 42(S1):s56-s68.

Alderdice DF, Velsen FPJ. 1971. Some Effects of Salinity and Temperautre on Early Development of Pacific Herring (Clupea pallasi). Journal of the Fisheries Research Board of Canada 28(10):1545-1562.

Arai MN, Hay DE. 1982. Predation by Medusae on Pacific Herring (*Clupea harengus pallasi*) Larvae. Canadian Journal of Fisheries and Aquatic Sciences 39(11):1537-1540.

Arnold T, Mealey C, Leahey H, Miller AW, Hall-Spencer JM, Milazzo M, Maers K. 2012. Ocean Acidification and the Loss of Phenolic Substances in Marine Plants. PLOS ONE 7(4):e35107.

Azat SP. 2003. Survival of Pacific Herring Eggs on Giant Kelp In San Francisco Bay [Master's Thesis]: San Francisco State University. 35 p.

Bakun A, Babcock EA, Santora C. 2009. Regulating a complex adaptive system via its wasp-waist: grappling with ecosystem-based management of the New England herring fishery. ICES Journal of Marine Science 66(8):1768-1775.

Baltz DM, Morejohn V. 1977. Food Habits and Niche Overlap of Seabirds Wintering on Monterey Bay, California. The Auk 94:526-543.

Bargmann G. 1998. Forage Fish Management Plan: A plan for managing the forage fish resources and fisheries of Washington. Olympia, Washington Washington Department of Fish and Wildlife.

Baumgartner T, A S, V F-B. 1992. Reconstruction of the history of Pacific sardine and northern anchovy populations over the past two millennia from sediments of the Santa Barbara Basin, California. CalCOFI Rep 33:24-40.

Baxter R, Hieb K, DeLeon S, Flemming K, Orsi J. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California. California Department of Fish and Game. 503 p.

Bayer RD. 1980. Birds feeding on herring eggs at the Yaquina Estuary, Oregon. The Condor 82:193-198.

Beacham TD, Schweigert JF, MacConnachie C, Le KD, Flostrand L. 2008. Use of Microsatellites to Determine Population Structure and Migration of Pacific Herring in British Columbia and Adjacent Regions. Transactions of the American Fisheries Society 137(6):1795-1811.

Becker BH, Beissinger SR. 2006. Centennial Decline in the Trophic Level of an Endangered Seabird after Fisheries Decline. Conservation Biology 20(2):470-479.

Berkeley SA, Chapman C, Sogard SM. 2004. Maternal Age as a Determinant of Larval Growth and Survival in a Marine Fish, Sebastes Melanops. Ecology 85(5):1258-1264.

Beverton RJH. 1990. Small marine pelagic fish and the threat of fishing; are they endangered? Journal of Fish Biology 37(sA):5-16.

Bird CJ, McLlachlan JL. 1992. Seaweed flora of the Maritimes. 1. Rhodophyta-The red algae. Bristol, England: Biopress. 177 p.

Bishop MA, Green SP. 2001. Predation on Pacific herring (*Clupea pallasi)* spawn by birds in Prince William Sound, Alaska. Fisheries Oceanography 10(suppl.1):149-158.

Black BA, Schroeder ID, Sydeman WJ, Bograd SJ, Lawson PW. 2010. Wintertime ocean conditions synchronize rockfish growth and seabird reproduction in the central California Current ecosystem. Canadian Journal of Fisheries and Aquatic Sciences 67(7):1149-1158.

Blaxter JHS. 1985. The Herring: A Successful Species? Canadian Journal of Fisheries and Aquatic Sciences 42(S1):s21-s30.

Blaxter JHS, Holliday FGT. 1963. The behaviour and physiology of herring and other clupeids. Advances in Marine Biology 1:261-393.
Blaxter JHS, Hoss DE. 1981. Startle Response in Herring: The Effect of Sound Stimulus Frequency, Size of Fish and Selective Interference With The Acoustico-Lateralis System. Journal of the Marine Biological Association of the United Kingdom 61(4):871-879.
Blaxter JHS, Hunter JR. 1982. The Biology of the Clupeoid Fishes. Advances in Marine Biology 20:1-223.
Boehlert GW, Morgan JB, Yoklavich MM. 1983. Effects of Volcanic Ash and Estuarine Sediment on the Early Life History Stages of the Pacific Herring, *Clupea harengus pallasi*. Corvallis, Oregon: Water Resources Research Institute, Oregon State University. Report nr WRRI-87.
Boehlert GW, Yoklavich MM. 1984. Carbon assimilation as a function of ingestion rate in larval pacific herring, *Clupea harengus pallasi* Valenciennes. Journal of Experimental Marine Biology and Ecology 79(3):251-262.
Bollens SM, Sanders AM. 2004. Ecology of Larval Pacific Herring in the San Francisco Estuary: Seasonal and Interannual Abundance, Distribution, Diet, and Condition. American Fisheries Society Symposium 39:15-35.
Brodeur RD, Buchanan JC, Emmett RL. 2014. Pelagic and demersal fish predators on juvenile and adult forage fishes in the Northern California Current: spatial and temporal variations. CalCOFI Rep 55:96-116.
Buckley TW, Tyler GE, Smith DM, Livingston PA. 1999. Food Habits of Some Commercially Important Groundfish off the Coasts of California, Oregon, Washington, and British Columbia. Alaska Fisheries Science Center: National Oceanic and Atmospheric Administration. Report nr NOAA Technical Memorandum NMFS-AFSC-102.
Burdick DM, Short FT. 1999. The effects of boat docks on eelgrass beds in coastal waters of Massachusetts. Environmental Management 23(2):231-240.
Butterworth DS. 2007. Why a management procedure approach? Some positives and negatives. ICES Journal of Marine Science 64(4):613-617.
Calambokidis J, Steiger GH, Rasmussen K, R. JU, Balcomb KC, P. PLdG, Z. MS, Jacobsen JK, Baker CS, Herman LM and others. 2000. Migratory destinations of humpback whales that feed off California, Oregon and Washington. Marine Ecology Progress Series 192:295-304.
California Department of Fish and Game. 1998. Final Environmental Document (FED), Pacific Herring Commercial Fishing Regulations (Sections 163, 163.5, and 164, Title 14, California Code of Regulations). In: State of California. The Natural Resources Agency, editor.
California Department of Fish and Game. 2001. California's Living Marine Resources: A Status Report.
California Department of Fish and Game. 2005. Final Supplemental Environmental Document, Pacific Herring Commercial Fishing Regulations (Sections 163, 163.5, and 164, Title 14, California Code of Regulations). In: State of California. The Natural Resources Agency, editor.
California Department of Fish and Game. 2015. Final Supplemental Environmental Document, Pacific Herring Commercial Fishing Regulations (Sections 163, 163.5, and 164, Title 14, California Code of Regulations). In: State of California. The Natural Resources Agency, editor.
California Department of Fish and Wildlife. 2018. 2018 Master Plan for Fisheries: A Guide for Implementation of the Marine Life Management Act. In: Agency. SoCTNR, editor.
Carls MG, Holland L, Larsen M, Collier TK, Scholz NL, Incardona JP. 2008a. Fish embryos are damaged by dissolved PAHs, not oil particles. Aquatic Toxicology 88(2):121-127.
Carls MG, Johnson SW, Lindeberg MR, Neff AD, Harris PM, Waples R. 2008b. Status Review of Lynn Canal Herring (*Clupea pallasii)* Seattle, Washington: Alaska Fisheries Science Center, National Marine Fisheries Service.

Carls MG, Marty GD, Hose JE. 2002. Synthesis of the toxicological impacts of the Exxon Valdez oil spill on Pacific herring (*Clupea pallasi*) in Prince William Sound, Alaska, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 59(1):153-172.

Carr JA, D'Odorico P, McGlathery KJ, Wiberg PL. 2012. Modeling the effects of climate change on eelgrass stability and resilience: future scenarios and leading indicators of collapse. Marine Ecology Progress Series 448:289-301.

Carruthers T, Hordyk A. 2017. DLMtool: data-limited methods toolkit. Version R package version 5.

Chavez FP, Collins CA, Huyer A, Mackas DL. 2002. El Niño along the west coast of North America. Prog Oceanogr 54(1):1-5.

Checkley JDM, Barth JA. 2009. Patterns and processes in the California Current System. Prog Oceanogr 83:49-64.

Chenillat F, Rivière P, Capet X, Lorenzo ED, Blanke B. 2012. North Pacific Gyre Oscillation modulates seasonal timing and ecosystem functioning in the California Current upwelling system. Geophysical Research Letters, American Geophysical Union 39:L01606.

Clapham PJ, Leatherwood S, Szczepaniak I, Brownell Jr RL. 1997. Catches of Humpback and Other Whals from Shore Stations at Moss Landing and Trinidad, California, 1919–1926. Marine Mammal Science 13(3):368-394.

Cleary JS, Taylor NG, Haist V. 2017. Status of B.C. Pacific Herring (*Clupea pallasii)* in 2013 and forecasts for 2014. Ottawa, Ontario: Fisheries and Oceans Canada.

Cochrane K, Young CD, Soto D, Bahri T. 2009. Climate change implications for fisheries and aquaculture Overview of current scientific knowledge. Rome: FAO.

Connor M, Hunt J, Werme C. 2005. Potential impacts of dredging on Pacific herring in San Francisco Bay. San Francisco Estuary Institute. 98 p.

Cope JM, Punt AE. 2009. Length-Based Reference Points for Data-Limited Situations: Applications and Restrictions. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2009:168-186.

Costa DP. 2008. A conceptual model of the variation in parental attendance in response to environmental fluctuation: foraging energetics of lactating sea lions and fur seals. Aquatic Conservation: Marine and Freshwater Ecosystems 17(S44-S52).

Costello M, C. Gamble J. 1992. Effects of sewage sludge on marine fish embryos and larvae. Marine Environmental Research 33(1):49-74.

Cox B, Hendrick R. 2001. VHS virus in Pacific sardines and mackerel. Newsletter for the American Fisheries Society Fish Health Section 29.

Crawford RJM, Underhill LG, Upfold L, Dyer BM. 2007. An altered carrying capacity of the Benguela upwelling ecosystem for African penguins (*Spheniscus demersus*). ICES Journal of Marine Science 64:570-576.

Crozier LG, Hutchings JA. 2014. Plastic and evolutionary responses to climate change in fish. Evolutionary Applications 7(1):68-87.

Cury PM, Boyd IL, Bonhommeau S, Anker-Nilssen T, Crawford RJM, Furness RW, Mills JA, Murphy EJ, Österblom H, Paleczny M and others. 2011. Global Seabird Response to Forage Fish Depletion—One-Third for the Birds. Science 334(6063):1703-1706.

Deriso RB, Maunder MN, Pearson WH. 2008. Incorporating Covariates Into Fisheries Stock Assessment Models with Application to Pacific Herring. Ecological Applications 18(5):1270-1286.

Di Lorenzo E, Mantua N. 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change 6:1042.

Di Lorenzo E, Schneider N, Cobb KM, Franks PJS, Chhak K, Miller AJ, McWilliams JC, Bograd SJ, Arango H, Curchitser E and others. 2008. North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophysical Research Letters 35(8):L08607.

Eguchi T, Harvey JT. 2005. Diving Behavior of the Pacific Harbor Seal (*Phoca vitulina richardii*) in Monterey Bay, California. Marine Mammal Science 21(2):283-295.

Eldridge MB, Kaill WM. 1973. San Francisco Bay Area 's Herring Resource - A Colorful Past and a Controversial Future. Marine Fisheries Review 35(11):25-31.

Emmett RL, Hinton SA, Stone SL, Monaco ME. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries Volume II: Species Life History Summaries. Rockville, MD: NOAA/NOS Strategic Environmental Asessments Division. Report nr ELMR Report Number 8. 329 p.

Emmett RL, Miller DR, Blahm TH. 1986. Food of juvenile chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, salmon off the northern Oregon and southern Washington coasts, May-September 1980. California Fish and Game 72(1):38-46.

Essington TE, Moriarty PE, Froehlich HE, Hodgson EE, Koehn LE, Oken KL, Siple MC, Stawitz CC. 2015. Fishing amplifies forage fish population collapses. Proceedings of the National Academy of Sciences of the United States of America 112(21):6648-6652.

Field JC, MacCall AD, Bradley RW, Sydeman WJ. 2010. Estimating the impacts of fishing on dependent predators: a case study in the California Current. Ecological Applications 20(8):2223-2236.

Fisheries and Oceans Canada. 2016. Stock Assessment and Management Advice for Pacific Herring: 2016 Status and 2017 Forecast. In: Canada Go, editor. Pacific Region.

Fleming AH, Clark CT, Calambokidis J, Barlow J. 2016. Humpback whale diets respond to variance in ocean climate and ecosystem conditions in the California Current. Glob Chang Biol 22(3):1214-1224.

Fleming K. 1999. Clupidae. In: Report on the 1980-1995 fish, shrimp and crab sampling in the San Francisco Estuary, California. The Interagency Ecological Program for San Francisco Estuary. 503 p.

Fossum P. 1996. A study of first-feeding herring (*Clupea harengus* L.) larvae during the period 1985–1993. ICES Journal of Marine Science 53:51-59.

Fresh KL. Some aspects of the trophic ecology of Pacific Herring in Puget Sound. In: Buchanan K, editor; 1981; Nanaimo, British Columbia. Department of Fisheries and Oceans. p 117.

Fresh KL, Cardwell RD, Koons RR. 1981. Food Habits of Pacific Salmon, Baitfish And Their Potential Competitors and Predators In the Marine Waters of Washington August 1978 to September 1979. State of Washington Department of Fisheries. 58 p.

García-Reyes M, Sydeman WJ. 2017. California Multivariate Ocean Climate Indicator (MOCI) and marine ecosystem dynamics. Ecological Indicators 72:521-529.

Garcia SM, Kolding J, Rice J, Rochet M-J, Zhou S, Arimoto T, Beyer JE, Borges L, Bundy A, Dunn D and others. 2012. Reconsidering the Consequences of Selective Fisheries. Science 335(6072):1045-1047.

Garza DA. 1996. The Southeast Alaska herring sac-roe fishery : a need for change? [Dissertation]: University of Delaware. 119 p.

Gentemann CL, Fewings MR, García-Reyes M. 2017. Satellite sea surface temperatures along the West Coast of the United States during the 2014–2016 northeast Pacific marine heat wave. Geophysical Research Letters 44(1):312-319.

Gibble CM. 2011. Food habits of harbor seals (*Phoca vitulina richardii*) in San Francisco Bay, California [Master's Thesis]: San Jose State University.

Gibson RN, Ezzi IA. 1985. Effect of particle concentration on filter- and particulate-feeding in the herring Clupea harengus. Marine Biology 88(2):109-116.

Gienapp P, Teplitsky C, Alho JS, Mills JA, Merila J. 2008. Climate change and evolution: disentangling environmental and genetic responses. Molecular Ecology 17(1):167-178.

Grant SW. 1986. Biochemical Genetic Divergence between Atlantic, *Clupea harengus*, and Pacific, *C. pallasi*, Herring. Copeia 1986(3):714-719.

Greiner T. in preparation. Survival from Egg to Age-3 of Pacific Herring (*Clupea pallasii*) in San Francisco Bay, evidence of Compensatory Density Dependence.

Griffin FJ, Brenner MR, Brown HM, Smith EH, Vines CA, Cherr GN. 2004. Survival of Pacific herring larvae is a function of external salinity. American Fisheries Society Symposium 39:37-46.

Griffin FJ, DiMarco T, Menard KL, Newman JA, Smith EH, Vines CA, Cherr GN. 2012. Larval Pacific Herring (*Clupea pallasii)* Survival in Suspended Sediment. Estuaries and Coasts 35(5):1229-1236.

Griffin FJ, Pillai MC, Vines CA, Kaaria J, Hibard-Robbins T, Ryuzo Y, Cherr GN. 1998. Effects of Salinity on Sperm Motility, Fertilization, and Development in the Pacific Herring, *Clupea pallasii*. Biological Bulletin 194(February):25-35.

Groner M, Burge C, Friedman C, Van Alstyne K, Wyllie-Echeverria S, Eisenlord M, Bucci J, Cox R, Turner M. Effects of Climate Change on Eelgrass Wasting Disease 2016. American Geophysical Union.

Gustafson RG, Drake JS, Ford MJ, Myers JM, Holmes EE, Waples RS. 2006. Status review of Cherry Point Pacific Herring (*Clupea pallasii*) and updated status review of the Georgia Basin Pacific Herring distinct population segment under the Endangered Species Act. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce.

Haegele CW, Schweigert JF. 1985. Distribution and characteristics of Herring spawning grounds and description of spawning behavior. Canadian Journal of Fisheries and Aquatic Sciences 42(S1):39-55.

Hardwick JE. 1973. Biomass estimates of spawning Herring, *Clupea harengus pallasii*, Herring eggs, and associated vegetation in Tomales Bay. California Fish and Game 59(1):36-61.

Hare SR, Mantua NJ. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog Oceanogr 47(2):103-145.

Hart JL. 1973. Pacific fishes of Canada. Ottawa, Ontario: Fisheries Research Board of Canada. 740 p.

Harvey CJ, Garfield N, Williams GD, Andrews KS, Barceló C, Barnas KA, Bograd SJ, Brodeur RD, Burke BJ, Cope JM and others. 2017. Ecosystem status report of the California Current for 2017 : A summary of ecosystem indicators compiled by the California Current Integrated Ecosystem Assessment Team (CCIEA).

Hay DE. 1985. Reproductive biology of Pacific Herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences 42(S1):111-126.

Hay DE. 1990. Tidal influence on spawning time of Pacific Herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences 47(12):2390-2401.

Hay DE. Reflections of factors affecting size-at-age and strong year classes of Herring in the North Pacific; 2002; Nemuro, Japan. North Pacific Marine Science Organization (PICES). p 94-97.

Hay DE, McCarter PB. Continental shelf area and distribution, abundance, and habitat of Herring in the North Pacific; 1997; Fairbanks, Alaska. University of Alaska, Fairbanks. p 559-572.

Hay DE, Outram DN. 1981. Assessing and monitoring maturity and gonad development in Pacific Herring. Pacific Biological Station, Nanaimo, British Columbia: Resource Services Branch, Department of Fisheries and Oceans. Report nr Canadian Technical Report of Fisheries and Aquatic Sciences No. 998. 38 p.

Hay DE, Rose KA, Schweigert J, Megrey BA. 2008. Geographic variation in North Pacific Herring populations: Pan-Pacific comparisons and implications for climate change impacts. Prog Oceanogr 77(2):233-240.

Hay DE, Schweigert J, Boldt J, Greiner T. 2012. Decrease in herring size-at-age: a climate change connection? In: Irvine JR, Crawford WR, editors. State of physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems in 2011: DFO Canadian Science Advisory Secretariat Research Document 2012/072 xi +142 p. p 66-69.

Hay DE, Toresen R, Stephenson R, Thompson M, Claytor R, Funk F, Ivshina E, Jakobsson J, Kobayashi T, McQuinn I and others. 2001. Taking Stock: An Inventory and Review of World Herring Stocks in 2000. In: Funk F, Blackburn J, Hay D, Paul AJ, Stephenson R, Toresen R,

Witherell D, editors. Herring: Expectations for a New Millennium. Fairbanks: University of Alaska Sea Grant College Program.
Henri M, Dodson JJ, Powles H. 1985. Spatial Configurations of Young Herring (*Clupea harengus harengus*) larvae in the St. Lawrence Estuary: Importance of Biological and Physical Factors. Canadian Journal of Fisheries and Aquatic Sciences 42(Supplemental 1):91-104.
Herrgesell PL, Schaffier RG, Larsen CJ. 1983. Effects of freshwater outflow on San Francisco Bay biological resources. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report No. 7. 1-86 p.
Hershberger PK, Kocan RM, Elder NE, Marty GD, Johnson J. 2001. Management of Pacific Herring spawn-on-kelp fisheries to optimize fish health and product quality. North American Journal of Fisheries Management 21(4):976-981.
Hershberger PK, Stick K, Bui B, Carroll C, Fall B, Mork C, Perry JA, Sweeney E, Wittouck J, Winton J and others. 2002. Incidence of *Ichthyophonus hoferi* in Puget Sound fishes and its increase with age of Pacific Herring. Journal of Aquatic Animal Health 14(1):50-56.
Hilborn R, Amoroso RO, Bogazzi E, Jensen OP, Parma AM, Szuwalski C, Walters CJ. 2017. When does fishing forage species affect their predators? Fisheries Research 191:211-221.
Hose JE, McGurk MD, Marty GD, Hinton DE, Brown ED, Baker TT. 1996. Sublethal effects of the Exxon Valdez oil spill on Herring embryos and larvae: morphological, cytogenetic, and histopathological assessments, 1989-1991. Canadian Journal of Fisheries and Aquatic Sciences 53(10):2355-2365.
Hourston AS, Haegele CW. 1980. Herring on Canada's Pacific coast. Canadian Journal of Fisheries and Aquatic Sciences 48(Special Publication):1-23.
Hourston AS, Rosenthal H, Kerr S. 1981. Capacity of juvenile Pacific Herring (*Clupea harengus pallasi*) to feed on larvae of their own species. Nanaimo, British Columbia: Department of Fisheries and Oceans, Resource Services Branch, Pacific Biological Station.
Incardona JP, Collier TK, Scholz NL. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicology and Applied Pharmacology 196(2):191-205.
Incardona JP, Vines CA, Anulacion BF, Baldwin DH, Day HL, French BL, Labenia JS, Linbo TL, Myers MS, Olson OP and others. 2012. Unexpectedly high mortality in Pacific Herring embryos exposed to the 2007 Cosco Busan oil spill in San Francisco Bay. Proceedings of the National Academy of Sciences 109(2):E51-E58.
Jacox MG, Hazen EL, Zaba KD, Rudnick DL, Edwards CA, Moore AM, Bograd SJ. 2016. Impacts of the 2015–2016 El Niño on the California Current System: Early assessment and comparison to past events. Geophysical Research Letters 43(13):7072-7080.
Jennings S, Kaiser MJ. 1998. The Effects of Fishing on Marine Ecosystems. Advances in Marine Biology 34:201-212.
Jones RE. 1981. Food habits of smaller marine mammals from Northern California. Proceedings of the California Academy of Sciences, 4th series 42:409-433.
Keller M. 1963. The growth and distribution of eelgrass (*Zostera marina* L.) in Humboldt Bay, California [Master's Thesis]. Arcata: Humboldt State University. 55 p.
Kieckhefer TR. 1992. Feeding ecology of humpback whales in continental shelf waters near Cordell Bank, California [Master's Thesis]: San Jose State University.
Kikuchi T, Peres JM. 1977. Consumer ecology of seagrass beds. In: McRoy CP, Helffrich C, editors. Seagrass ecosystems: a scientific perspective. New York Marcel Dekker, Inc. p 147-193.
Kimmerer WJ. 2002a. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55.
Kimmerer WJ. 2002b. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25(6):1275-1290.
Kiørboe T, Munk P. 1986. Feeding and growth of larval Herring, *Clupea harengus*, in relation to density of copepod nauplii. Environmental Biology of Fishes 17(2):133-139.

Kocan R, Bradley M, Elder N, Meyers T, Batts W, Winton J. 1997. The North American strain of viral hemorrhagic septicemia virus is highly pathogenic for laboratory-reared Pacific Herring (*Clupea pallasi*). Journal of Aquatic Animal Health 9(4):279-290.

Kvamme C, Nottestad L, Ferno A, Misund OA, Dommasnes A, Axelson BE. 2000. A sonar study of the migration pattern of Norwegian spring-spawning Herring (*Clupea harengus L.*) in July. ICES Journal of Marine Science CM 2000(K:14):1-24.

Lambert TC. 1987. Duration and intensity of spawning in Herring *Clupea harengus* as related to the age structure of the mature population. Marine Ecology Progress Series 39:209-220

Lassuy DR, Moran D. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest) Pacific Herring. Report nr TR EL-82-4.

Law R. 2000. Fishing, selection, and phenotypic evolution. ICES Journal of Marine Science 57(3):659-668.

Law R. 2007. Fisheries-induced evolution: present status and future directions. Marine Ecology Progress Series 335:271-277.

Lindley ST, Grimes CB, Mohr MS, Peterson W, Stein J, Anderson JT, Botsford LW, Bottom DL, Busack CA, Collier TK and others. 2009. What caused the Sacramento River fall Chinook stock collapse?

Litz MNC, Miller JA, Brodeur RD, Daly EA, Weitkamp LA, Hansen AG, Claiborne AM. 2018. Energy dynamics of subyearling Chinook salmon reveal the importance of piscivory to short-term growth during early marine residence. Fisheries Oceanography 2018(0):1-17.

Liu JX, Tatarenkov A, Beacham TD, Gorbachev V, Wildes S, Avise JC. 2011. Effects of Pleistocene climatic fluctuations on the phylogeographic and demographic histories of Pacific Herring (*Clupea pallasii*). Molecular Ecology 20(18):3879-3893.

Lok EK, Kirk M, Esler D, Boyd WS. 2008. Movements of Pre-Migratory Surf and White-Winged Scoters in Response to Pacific Herring Spawn. Waterbirds: The International Journal of Waterbird Biology 31(3):385-393.

Lowry MS, Forney K. 2005. Abundance and distribution of California sea lions (Zalophus califomianus) in central and northern California during 1998 and summer 1999.

MacCall AD, Maunder M, Schweigert J. 2003. Peer review of the California Department of Fish and Game's commercial Pacific Herring fishery management and the use of the Coleraine fishery model.

MacCall AD, Sydeman WJ, Davison PC, Thayer JA. 2016. Recent collapse of Northern Anchovy biomass off California. Fisheries Research 175:87-94.

Marty GD, Quinn TJI, Carpenter G, Meyers TR, Willits NH. 2003. Role of disease in abundance of a Pacific Herring (*Clupea pallasi*) population. Canadian Journal of Fisheries and Aquatic Sciences 60(10):1258-1265.

McEwan DR. 2001. Central Valley Steelhead. In: Brown R, editor. Fish and Game Bulletin No 179. Sacramento, Ca: California Department of Fish and Game. p 1-44.

McFarlane G, Schweigert J, MacDougall L, Hrabok C. 2005. Distribution and biology of Pacific Sardines (*Sardinops sagax*) off British Columbia, Canada. California Cooperative Oceanic Fisheries Investigations Report 46:144-160.

McGurk MD. 1984. Effects of delayed feeding and temperature on the age of irreversible starvation and on the rates of growth and mortality of Pacific Herring larvae. Marine Biology 84(1):13-26.

McGurk MD, Brown ED. 1996. Egg larval mortality of Pacific Herring in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Canadian Journal of Fisheries and Aquatic Sciences 53(10):2343-2354.

McKechnie I, Lepofsky D, Moss ML, Butler VL, Orchard TJ, Coupland G, Foster F, Caldwell M, Lertzman K. 2014. Archaeological data provide alternative hypotheses on Pacific Herring (*Clupea pallasii*) distribution, abundance, and variability. Proceedings of the National Academy of Sciences 111(9):E807-E816.

Melin SR, Orr AJ, Harris JD, Laake JL, Delong RL, Gulland F, Stoudt S. 2010. Unprecedented mortality of California sea lion pups associated with anomalous oceanographic conditions along the central California coast in 2009. Invest Rep 51:182-194.

Mello JJ. 2006. Summary of 2005-06 Pacific Herring spawning ground surveys and commercial catch in Humboldt Bay and Crescent City. California Department of Fish and Game Technical Report.

Merkel and Associates. 2014. San Francisco Bay Eelgrass Inventory. Santa Rosa, California: Report for the National Marine Fisheries Service.

Merkel and Associates. 2016. Noyo River and Harbor Maintenance Dredging Pre-dredge Eelgrass Survey Results Transmittal. Prepared for U.S. Army Corps of Engineers San Francisco District, .

Merkel and Associates. 2017. Tomales Bay Eelgrass Inventory. Report nr M&A #05-024-38.

Merkel TJ. 1957. Food habits of the King Salmon, *Oncorhynchus tshawytscha* (Walbaum), in the vicinity of San Francisco, California. California Fish and Game 43(4):249-270.

Messieh SN, Wildish DJ, Peterson RH. 1981. Possible impact of sediment from dredging and spoil disposal on the Miramichi Bay Herring fishery. Canadian Technical Report Fisheries Aquatic Sciences No. 1008.

Miller DJ, Lea RN. 1972. Guide to the coastal marine fishes of California (No. 154-158). Sacramento, California: University of California Agriculture and Natural Resources Publications.

Miller DJ, Schmidtke J. 1956. Report on the distribution and abundance of Pacific Herring (*Clupea pallasi*) along the coast of central and southern California. California Fish and Game 42:163-187.

Moller H. 1984. Reduction of a Larval Herring Population by Jellyfish Predator. Science 224(4649):621.

Moore TO, Reilly PN. 1989. Pacific Herring, *Clupea harengus pallasi*, experimental roe-on-kelp open pound fishery studies in San Francisco Bay, December 1987 to February 1988. Report nr 89-3. 35 p.

Moser M, Hsieh J. 1992. Biological tags for stock separation in Pacific Herring *Clupea harengus pallasi* in California. J Parasitol 78(1):54-60.

Myers RA, Bowen KG, Barrowman NJ. 1999. Maximum reproductive rate of fish at low population sizes. Canadian Journal of Fisheries and Aquatic Sciences 56(12):2404-2419.

National Oceanic and Atmospheric Administration. 2014a. California Sea Lion (*Zalophus californianus*): U.S. Stock.

National Oceanic and Atmospheric Administration. 2014b. Pacific Herring. Alaska Regional Office.

Nejrup LB, Pedersen MF. 2008. Effects of salinity and water temperature on the ecological performance of *Zostera marina*. Aquatic Botany 88(3):239-246.

Norcross BL, Brown ED. 2001. Estimation of first year survival of Pacific Herring from a review of recent stage-specific studies. In: Funk F, Blackburn J, Hay D, Paul AJ, Stephenson R, Toresen R, Witherell D, editors. Herring: expectations for a new millennium. Fairbanks, Alaska: University of Alaska Sea Grant, AK-SG-01-04.

Norcross BL, Brown ED, Foy RJ, Frandsen M, Gay SM, Kline TC, Jr., Mason DM, Patrick EV, Paul AJ, Stokesbury KDE. 2001. A synthesis of the life history and ecology of juvenile Pacific herring in Prince William Sound, Alaska. Fisheries Oceanography 10(suppl.1):42-57.

Norcross BL, Hose JE, Frandsen M, Brown ED. 1996. Distribution, abundance, morphological condition, and cytogenetic abnormalities of larval Herring in Prince William Sound, Alaska, following the (Exxon Valdez) oil spill. Canadian Journal of Fisheries and Aquatic Sciences 53(10):2376-2387.

Norton DW, Senner SE, Gill Jr RE, Martin PD, Wright JM, Fukuyama AK. 1990. Shorebirds and Herring roe in Prince William Sound, Alaska. American Birds 44(3):367-508.

O'Farrell MR, Mohr MS, Palmer-Zwahlen ML, Grover AM. 2013. The Sacramento Index (SI). In: Service NMF, editor. Southwest Fisheries Science Center: National Oceanic and Atmospheric Administration.
Ogle S. 2005. A review of scientific information on the effects of suspended sediments on Pacific Herring (*Clupea pallasi*) reproductive success. Martinez, California: US Army Corps of Engineers.
Outram DN. 1958. The magnitude of Herring spawn losses due to bird predation on the west coast of Vancouver Island. Fisheries Research Board of Canada Pacific Progress Report 111:9-13.
Outram DN, Humphreys RD. 1974. The Pacific Herring in British Columbia Waters. Fisheries and Marine Service, Pacific Biological Station Circulation 100:1-26.
Oxman DS. 1995. Seasonal abundance, movements, and food habits of harbor seal (*Phoca vitulina richardsi*) in Elkhorn Slough, California [Master's Thesis]: California State University, Stanislaus.
Pacific Fisheries Management Council. 1982. Pacific Herring Fishery Management Plan (Draft). Portland, Oregon. 131 p.
Pacific Fishery Management Council. 2011. Pacific Coast Salmon Fishery Management Plan Amendment 16: Stock Classification, Status Determination Criteria, Annual Catch Limits and Accountability Measures, and De Minimis Fishing Provisions. Appendix C: Chinook Fmsy Proxy Development. In: Pacific Fisheries Management Council, editor. Portland, Oregon.
Pacific Fishery Management Council. 2019. Preseason Report I: Stock Abundance Analysis and Environmental Assessment Part 1 for 2019 Ocean Salmon Fishery Regulations (Document prepared for the Council and its advisory entities.). 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384: Pacific Fishery Management Council.
Palacios SL, Zimmerman RC. 2007. Response of eelgrass *Zostera marina* to CO_2 enrichment: possible impacts of climate change and potential for remediation of coastal habitats. Marine Ecology Progress Series 344:1-13.
Paulson AC, Smith RL. 1977. Latitudinal Variation of Pacific Herring Fecundity. Transactions of the American Fisheries Society 106(3):244-247.
Perez MA, Bigg MA. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fishery Bulletin 84(4):957-971.
Petrou E, others. in preparation. Mechanisms contributing to limited dispersal in a pelagic fish (Clupea pallasii).
Phillips RC. 1978. Seagrasses and the Coastal Marine Environment. Oceanus 21:30-40.
Phillips RC. 1984. Ecology of eelgrass meadows in the Pacific northwest: A community profile. US Fish and Wildlife Service Report, 85 pp. 85 p.
Pikitch E, Boersma P, Boyd IL, Conover D, Cury P, Essington T, Heppell S. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. In: Mangel M, Pauly D, Plaganyi E, Sainsbury K, Steneck RS, editors. Washington, D.C.: Lenfest Ocean Program. p 108.
Punt AE. 2015. Strategic management decision-making in a complex world: quantifying, understanding, and using trade-offs. ICES Journal of Marine Science 74(2):499-510.
Punt AE, Butterworth DS, de Moor CL, De Oliveira JAA, Haddon M. 2016. Management strategy evaluation: best practices. Fish and Fisheries 17(2):303-334.
Purcell JE, Grover JJ. 1990. Predation and food limitation as causes of mortality in larval Herring at a spawning ground in British Columbia Canada. Marine Ecology Progress Series 59(1-2):55-62.
Purcell JE, Siferd TD, Marliave JB. 1987. Vulnerability of larval Herring (*Clupea harengus pallasi*) to capture by the jellyfish *Aequorea victoria*. Marine Biology 94(2):157-162.
Rabin DJ, Barnhart RA. 1977. Fecundity of Pacific Herring, *Clupea harengus pallasi*, in Humboldt Bay. California Fish and Game 63(3):193-196.

Rabin DJ, Barnhart RA. 1986. Population characteristics of Pacific herring, *Clupea harengus pallasi*, in Humboldt Bay, California. California Fish and Game 72(1):4-16.
Ralston S, Field JC, Sakuma KM. 2015. Long-term variation in a central California pelagic forage assemblage. Journal of Marine Systems 146:26-37.
Reilly PN, Moore TO. 1983. Pacific Herring, *Clupea Harengus Pallasi*, studies in San Francisco Bay, Monterey Bay, and the Gulf of the Farallones, July 1982 to March 1983. California Department of Fish and Game, Marine Resources, Administrative Report 83-5:1-49.
Reilly PN, Moore TO. 1984. Pacific Herring, *Clupea hrengus pallasi*, studies in San Francisco Bay, Monterey Bay, and the Gulf of the Farallones, May 1983 to March 1984. California Department of Fish and Game, Marine Resources, Administrative Report 84-3:1-67.
Reilly PN, Moore TO. 1985. Pacific Herring, *Clupea harengus pallasi*, studies in San Francisco Bay and the Gulf of the Farallones, June 1984 to March 1985. California Department of Fish and Game, Marine Resources, Administrative Report 85-4:1-73.
Reilly PN, Moore TO. 1986. Pacific Herring, *Clupea harengus pallasi*, studies in San Francisco Bay, central and northern California, and Washington, March 1985 to May 1986. California Department of Fish and Game, Marine Resources, Administrative Report 86-6:1-88.
Reilly PN, Moore TO. 1987. Pacific Herring, *Clupea harengus pallasi*, studies in San Francisco Bay, April 1986 to March 1987 California Department of Fish and Game, Marine Resources, Administrative Report 87-15:1-73.
Reum JCP, Essington TE, Greene CM, Rice CA, Fresh KL. 2011. Multiscale influence of climate on estuarine populations of forage fish: the role of coastal upwelling, freshwater flow and temperature. Marine Ecology Progress Series 425:203-215.
Rice SD, Moran JR, Straley JM, Boxwell KM, Heintz RA. 2011. Significance of whale predation on natural mortality rate of Pacific Herring in Prince William Sound. Juneau, Alaska: National Marine Fisheries Service. 25 p.
Ricker WE. 1975. Computation and interpretation of Biological Statistics of Fish Populations. Ottawa, Canada.
Robins CR, Bailey RM, Bond CE, Brooker JR, Lachner EA, Lea RN, Scott WB. 1991. Common and scientific names of fishes from the United States and Canada. Bethesda, Maryland: American Fisheries Society. 183 p.
Robinson H, Thayer J, Sydeman WJ, Weise M. 2018. Changes in California sea lion diet during a period of substantial climate variability. Marine Biology 165:169.
Roel BA, Walker ND, De Oliveira JAA. 2016. San Francisco Bay Herring Stock Assessment and Initial Evaluation of Harvest Control Rules.
Rooper CN, Haldorson LJ, Quinn TJ. 1999. Habitat factors controlling Pacific Herring (*Clupea pallasi*) egg loss in Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 56(6):1133-1142.
Rosenthal RJ, Moran-O'CoMell V, Murphy MC. 1988. Feeding ecology often species of rockfish (Scorpaenidae) from the Gulf of Alaska. California Fish and Game 74(1):16-37.
Rounsefell GA. 1930. Contribution to the biology of the Pacific Herring *Clupea pallasii* and the condition of the fishery in Alaska. United States Bureau of Fisheries 45.
Rumrill SS, Poulton VK. 2004. Ecological role and potential impacts of molluscan shellfish culture in the estuarine environment of Humboldt Bay, CA. Seattle, Washington: Western Regional Aquaculture Center. 44 p.
Rykaczewski RR, Checkley DM. 2008. Influence of ocean winds on the pelagic ecosystem in upwelling regions. Proceedings of the National Academy of Sciences 105(6):1965-1970.
Sakuma K. 2017. Rockfish Recruitment and Ecosystem Assessment Cruise Report. National Oceanic and Atmospheric Administration. Report nr RL-17-03 (OMAO). 20 p.
Sanchez GM, Gobalet KW, Jewett R, Cuthrell RQ, Grone M, Engel PM, Lightfoot KG. 2018. The historical ecology of central California coast fishing: Perspectives from Point Reyes National Seashore. Journal of Archaeological Science 100:1-15.

Santora JA, Hazen EL, Schroeder ID, Bograd SJ, Sakuma KM, Field JC. 2017. Impacts of ocean climate variability on biodiversity of pelagic forage species in an upwelling ecosystem. Marine Ecology Progress Series 580(205-220).

Schloesser RW, Fabrizio MC. 2017. Condition Indices as Surrogates of Energy Density and Lipid Content in Juveniles of Three Fish Species Transactions of the American Fisheries Society 146(5):1058-1069.

Schlosser S, Eicher A. 2012. The Humboldt Bay and Eel River Estuary Benthic Habitat Project. 246 p.

Schwarz AL, Greer GL. 1984. Responses of Pacific Herring, *Clupea harengus pallasi*, to Some Underwater Sounds. Canadian Journal of Fisheries and Aquatic Sciences 41(8):1183-1192.

Schweigert J, Funk F, Oda K, Moore T. Herring size-at-age variation in the North Pacific. Pices-Globec International Program on Climate Change and Carrying Capacity; 2002; Victoria, British Columbia, Canada. p 76.

Schweigert JF, Boldt JL, Flostrand L, Cleary JS. 2010. A review of factors limiting recovery of Pacific Herring stocks in Canada. ICES Journal of Marine Science 67(9):1903-1913.

Scofield NB. 1918. The Herring and the development of the Herring industry in California. California Fish and Game 4(2):65-70.

Shields TL, Jamieson GS, Sprout PE. 1985. Spawn-on-kelp fisheries in the Queen Charlotte Islands and northen British Columbia Coast - 1982 and 1983. Canadian Technical Report of Fisheries and Aquatic Sciences 1372:53.

Short FT, Muehlstein LK, Porter D. 1987. Eelgrass wasting disease: Cause and recurrence of a marine epidemic. Biological Bulletin 173(3):557-562.

Short FT, Neckles HA. 1999. The effects of global climate change on seagrasses. Aquatic Botany 63(3):169-196.

Sigler MF, Csepp DJ. 2007. Seasonal abundance of two important forage species in the North Pacific Ocean, Pacific Herring and Walleye Pollock. Fisheries Research 83(2-3):319-331.

Siple MC, Francis TB. 2016. Population diversity in Pacific Herring of the Puget Sound, USA. Oecologia 180(1):111-125.

Smith ADM. Management strategy evaluation: the light on the hill. In: Hancock DA, editor; 1993; Perth, WA. Australian Society for Fish Biology. p 249-253.

Smith ADM, Brown CJ, Bulman CM, Fulton EA, Johnson P, Kaplan IC, Lozano-Montes H, Mackinson S, Marzloff M, Shannon LJ and others. 2011. Impacts of Fishing Low–Trophic Level Species on Marine Ecosystems. Science 333(6046):1147-1150.

Soto KH, Trites AW, Arias-Schreiber M. 2004. The effects of prey availability on pup mortality and the timing of birth of South American sea lions (*Otaria flavescens*) in Peru. Journal of Zoology 264(4):419-428.

Spratt J. 1986. Biomass estimates of Pacific herring, Clupea harengus pallasi, in California from the 1985–86 spawning-ground surveys. California Department of Fish and Game, Marine Resources Division. 28 p.

Spratt JD. 1981. Status of the Pacific Herring, *Clupea harengus pallasii* , resource in California 1972 to 1980. California Department of Fish and Game Fish Bulletin: The Resources Agency, State of California. p 107.

Spratt JD. 1984. Biomass estimate of Pacific Herring, *Clupea harengus pallasi*, in California from teh 1983-84 spawning ground surveys. California Department of Fish and Game. Report nr 84-2. 32 p.

Spratt JD. 1987. Variation in the growth rate of Pacific Herring from San Francisco Bay, California. California Fish and Game 73(3):132-138.

Spratt JD. 1992. The evolution of California's Herring roe fishery: Catch allocation, limited entry, and conflict resolution. California Fish and Game 78(1):20-44.

Spratt JD, Moore TO, Collier P. 1992. Biomass estimates of Pacific Herring, *Clupea pallasi*, in California from the 1991-92 spawning-ground surveys. California Department of Fish and Game. Report nr 92-2. 43 p.

Stacey NE, Hourston AS. 1982. Spawning and Feeding Behavior of Captive Pacific Herring, *Clupea harengus pallasi*. Canadian Journal of Fisheries and Aquatic Sciences 39(3):489-498.
Steinfeld JD. 1971. Distribution of Pacific Herring spawn in Yaquina Bay, Oregon, and observations on mortality through hatching [Masters Thesis]: Oregon State University. 89 p.
Stevenson JC. 1962. Distribution and Survival of Herring Larvae (*Clupea pallasi* Valenciennes) in British Columbia Waters. Journal of the Fisheries Research Board of Canada 19(5):735-810.
Stick KC, Lindquist A, Lowry D. 2014. 2012 Washington state Herring stock status report.: Washington Department of Fish and Wildlife, State of Washington. 97 p.
Stokes TK, Elythe SP. Size-Selective Harvesting and Age-At-Maturity II: Real Populations and Management Options. The Exploitation of Evolving Resources; 1993; Berlin, Heidelberg. Springer Berlin Heidelberg. p 232-247.
Stokesbury K, Kirsch J, Vincent Patrick E, Norcross B. 2002. Natural mortality estimates of juvenile Pacific Herring (*Clupea pallasi*) in Prince William Sound, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 59(3):416-423.
Stokesbury KDE, Brown ED, Foy RJ, Seitz J, Norcross BL. 1998. Exxon Valdez oil spill restoration project annual report: juvenile Herring growth habitats. Fairbanks, Alaska: Institute of Marine Science, University of Alaska, Fairbanks.
Suer AL. 1987. The Herring of San Francisco and Tomales Bays. San Francisco, California: The Ocean Research Institute. 64 p.
Sunada JS, Yamashita IK, Kelly PR, Gress F. 1981. The Brown Pelican as a sampling instrument of age group structure in the Northern Anchovy population. Invest Rep 22:65-68.
Sydeman WJ, García-Reyes M, Szoboszlai AI, Thompson SA, Thayer JA. 2018. Forecasting herring biomass using environmental and population parameters. Fisheries Research 205:141-148.
Sydeman WJ, Hester MM, Thayer JA, Gress F, Martin P, Buffa J. 2001. Climate change, reproductive performance and diet composition of marine birds in the southern California Current system, 1969–1997. Prog Oceanogr 49:309-329.
Szoboszlai A, Thayer J, Sydeman W, Koehn L. in revision. Estimating predator consumption of anchovy and sardine in the California Current.
Szoboszlai AI, Thayer JA, Wood SA, Sydeman WJ, Koehn LE. 2015. Forage species in predator diets: Synthesis of data from the California Current. Ecological Informatics 29:45-56.
Tanasichuk RW. 1997. Influence of biomass and ocean climate on the growth of Pacific Herring (*Clupea pallasi*) from the southwest coast of Vancouver Island. Canadian Journal of Fisheries and Aquatic Sciences 54(12):2782-2788.
Tanasichuk RW. 2000. Age-specific natural mortality rates of adult Pacific Herring (*Clupea pallasi*) from southern British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 57(11):2258-2266.
Tester AL. 1937. Populations of Herring (*Clupea pallasii*) in the Coastal Waters of British Columbia. Journal of the Biological Board of Canada 3(2):108-144.
Tester AL. 1942. A high mortality of herring eggs. Fisheries Research Board of Canada. 16-19 p.
Thayer GW, Wolfe DA, Williams RB. 1975. The impact of man on seagrass systems. American Scientist 63(3):288-296.
Thayer JA, Field JC, Sydeman WJ. 2014. Changes in California Chinook salmon diet over the past 50 years: relevance to the recent population crash. Marine Ecology Progress Series 498:249-261.
Thompson SA, Sydeman WJ, Thayer JA, Weinstein A, Krieger KL, Hay D. 2017. Trends in the Pacific Herring (*Clupea pallasii*) metapopulation in the California Current Ecosystem. California Cooperative Oceanic Fisheries Investigations, Progress Report 58:1-18.
Thorne R, Thomas GL. 1990. Acoustic observations of gas bubble release by Pacific Herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences 47(10):1920-1928.

Thornton TF, Butler V, Funk F, Moss M, Hebert J, Elder T. 2010. Herring Synthesis: Documenting and modeling Herring spawning areas within socioecological systems over time in the Southeastern Gulf of Alaska.

Tojo N, Kruse GH, Funk FC. 2007. Migration dynamics of Pacific Herring (*Clupea pallasii*) and response to spring environmental variability in the southeastern Bering Sea. Deep Sea Research Part II: Topical Studies in Oceanography 54(23):2832-2848.

Tommasi D, Stock CA, Pegion K, Vecchi GA, Methot RD, Alexander MA, Checkley Jr. DM. 2017. Improved management of small pelagic fisheries through seasonal climate prediction. Ecological Applications 27(2):378-388.

Torok ML. 1994. Movements, daily activity patterns, dive behavior, and food habits of harbor seals (*Phoca vitulina richardsi*) in San Francisco Bay, California: California State University, Stanislaus.

Trumble SJ. 1995. Food habits, dive behavior, and mother-pup interactions of harbor seals (Phoca vitulina richardsi) near Monterey Bay, California: Fresno State University.

Vines CA, Robbins T, Griffin FJ, Cherr GN. 2000. The effects of diffusible creosote-derived compounds on development in Pacific Herring (*Clupea pallasi*). Aquatic Toxicology 51(2):225-239.

Von Westernhagen H. 1988. Sublethal effects of pollutants on fish eggs and larvae. In: Hoar WS, Randall DJ, editors. Fish Physiology New York: Academic Press. p 253-346.

Walters CJ, Martell SJD. 2004. Fisheries Ecology and Management. Princeton, New Jersey: Princeton University Press.

Walther G-R, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin J-M, Hoegh-Guldberg O, Bairlein F. 2002. Ecological responses to recent climate change. Nature 416:389.

Ware DM. 1985. Life history characteristics, reproductive value, and resilience of Pacific Herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences 42(S1):127-139.

Ware DM, Tanasichuk RW. 1989. Biological basis of maturation and spawning waves in Pacific Herring (*Clupea harengus pallasi*). Canadian Journal of Fisheries and Aquatic Sciences 46(10):1776-1784.

Wasson K, Eby R, Endris C, Fork S, Haskins J, Hughes B, Jeppesen R, Dyke EV, Watson E. 2019. Elkhorn Slough, California: State of the Estuary Report.

Watters DL, Brown HM, Griffin FJ, Larson EJ, Cherr GN. 2004. Pacific Herring Spawning Grounds in San Francisco Bay: 1973–2000. American Fisheries Society Symposium 39:3-14.

Watters DL, Oda KT. 1997. Pacific Herring, *Clupea pallasi*, spawning population assessment for San Francisco Bay, 1992-93. California Department of Fish and Game. Report nr 97-3. 30 p.

Watters DL, Oda KT. 2002. Pacific herring, *Clupea pallasi*, spawning population assessment and fishery management for San Francisco Bay, 1993-94. California Department of Fish and Game. Report nr 02-1. 36 p.

Weathers DL, Kelly JP. 2007. The importance of ephemeral food abundance to wintering waterbirds. The Ardeid:4-6.

Weise MJ, Harvey JT. 2008. Temporal variability in ocean climate and California sea lion diet and biomass consumption: implications for fisheries management. Marine Ecology Progress Series 373:157–172.

Wells BK, Santora JA, Henderson MJ, Warzybok P, Jahncke J, Bradley RW, Huff DD, Schroeder ID, Nelson P, Field JC and others. 2017. Environmental conditions and prey-switching by a seabird predator impact juvenile salmon survival. 174:54-63.

Wheeler JP, Purchase CF, Ye C, Wang H, Jacks L, Macdonald PDM, Fill R. 2009. Temporal changes in maturation, mean length-at-age, and condition of spring-spawning Atlantic Herring (*Clupea harengus*) in Newfoundland waters. ICES Journal of Marine Science 66(8):1800-1807.

Willson MF, Womble JN. 2006. Vertebrate exploitation of pulsed marine prey: a review and the example of spawning herring. Reviews in Fish Biology and Fisheries 16(2):183-200.

Womble JN, Sigler MF. 2006. Seasonal availability of abundant, energy-rich prey influences the abundance and diet of a marine predator, the Steller sea lion *Eumetopias jubatus*. Marine Ecology Progress Series 325:281-293.

Wyatt B, Barton G, Strong R. 1986. Market potential for Pacific roe Herring. Santa Rosa, California. 29 p.

Ying Y, Chen Y, Lin L, Gao T. 2011. Risks of ignoring fish population spatial structure in fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 68(12):2101-2120.

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M e m o r a n d u m

Received September 25, 2019.
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Date: September 24, 2019

To: Melissa Miller-Henson
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: Agenda item for October 9-10, 2019 Fish and Game Commission Meeting Re: Receipt of the Final Draft California Pacific Herring Fishery Management Plan

The Department of Fish and Wildlife (Department) requests the Fish and Game Commission (Commission) receive the Final Draft California Pacific Herring Fishery Management Plan (Final Draft Herring FMP) for its October meeting.

The Final Draft Herring FMP includes 'Appendix S Public Comments Received, Responses, and Changes to the Draft California Pacific Herring Fishery Management Plan,' which summarizes public comments received by the Commission during the public comment period, Department responses for how public comments were addressed, and changes since June 2019 that have been incorporated into the Final Draft Herring FMP.

Authorization of this request for receipt will allow for possible adoption at the October 9-10, 2019 meeting.

If you have any questions or need additional information, please contact Dr. Craig Shuman, Marine Regional Manager at (916) 445-6459.

Attachment
Final Draft California Pacific Herring Fishery Management Plan

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Pacific Herring Fishery Management Plan

Adoption Hearing

Fish and Game Commission Meeting
Valley Center, CA
October 10, 2019

Dr. Craig Shuman
Marine Regional Manager
California Department of Fish and Wildlife

CDFW photo

Herring FMP Comments Received

1. Recreational take limit
2. Content corrections
3. Environmental concerns
4. Support of FMP adoption

CDFW photo

Department Response to Comments

1. Recreational take limit

   Proposed limit allows participants a satisfying recreational experience

2. Content corrections

   Recommendations for corrections and clarification adopted when appropriate

CDFW photo

Department Response to Comments

3. Environmental concerns
   Recommendations for environmental concerns adopted when appropriate

4. Support of FMP adoption
   The Department appreciates the support

Thank you

For more information please contact:
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Marine Region, Department of fish and Wildlife
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CDFW photo

OCEANA

September 24, 2019

Eric Sklar, President
California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

RE: Agenda items 17 and 18: Pacific herring FMP and regulations

Dear President Sklar and Commissioners:

We write in support of the Herring Fishery Management Plan (FMP) and associated implementing regulations under your consideration for adoption. Pacific herring help create the foundation of a healthy ocean ecosystem off California as a critically important forage species. Humpback whales, killer whales, porpoises, salmon, California sea lions, northern fur seals, and dozens of other ocean animals rely upon herring as a rich source of nutrients. It is essential that strong, precautionary management policies remain in place for Pacific herring in California as proposed in the FMP.

We commend the leadership shown by the Commission and the California Department of Wildlife in managing the herring fishery in a precautionary way over the last decade. San Francisco Bay is by far the largest spawning area for herring along the entire U.S. West Coast, and the only place where herring are commercially fished in California. The FMP would be among the first to allow adjustments to annual catch limits based on ecological information, such as the status of major herring predators and the availability of other similar forage species. In addition, the FMP would develop a precautionary approach to any new or resumed fishing in other major spawning areas including Tomales Bay, Humboldt Bay, and Crescent City. Adopting the herring FMP and implementing regulations under your consideration will advance implementation of the Commission's Forage Species policy and help ensure that the current responsible fishery management continues into the future. The FMP will provide for sustainable catch limits, population recovery and an abundant food supply for the animals that eat herring.

Please protect herring as a vital food source for wildlife and ensure a sustainable herring fishery by adopting the FMP and associated regulations to implement the plan.

Sincerely,

3,091 residents of the state of California

First Name	Last Name	City	Zip Code
Johanna	Abate	San Francisco	94109-4633
Marrisha	Abbot	Boulder Creek	95006-9564
Rebecca	Abbott	Concord	94518
Linda	Abbott Trapp	Valley Springs	95252
Suzanne	Abecket	Cupertino	95014
Mimi	Abers	Berkeley	94707-2624
Mary	Able	McArthur	96056

Anthony	Aboumrad	Santa Rosa	95401
Carroll	Abshier	Lakewood	90713
Sarah	Acorda	Indian Wells	92210
Alberto	Acosta	Burbank	91505-3939
Mike	Acosta	Riverside	92504-3935
Steven	Acosta	Los Angeles	90011-5900
Louis	Adamo	Redwood City	94063-0041
Paula	Adams	Pasadena	91107
L.	Adams	Escondido	92026-6210
Marge	Adams	San Jose	95118
Ron	Adams	Oakland	94611-1842
Elizabeth	Adams	Oakland	94602-2544
James	Adams	Sacramento	95827-1060
Julie	Adelson	Santa Monica	90405-4340
Steve	Aderhold	Fallbrook	92088-1135
Elise	Adibi	Los Angeles	90042
Pat	Adler	Santa Barbara	93105-2336
Jill	Adler	Manteca	95337-9009
Gloria	Aguirre	Castaic	91384
Hoda	Aguirre	Chino	91710
Natalie	Aharonian	North Hollywood	91605-3944
Roberta	Ahlquist	San Jose	95192-1000
Karen	Ahn	Sebastopol	95472-3054
Evelyn	Ahumada	Garden Grove	92840
Katherine	Aker	Tujunga	91042-1816
Elena	Albanese	Tarzana	91356-2318
Shan	Albert	Studio City	91604-1302
Gloria	Albert	Santa Monica	90403-2950
Jennifer	Alcivar	San Francisco	94116
Judith	Aldana	San Pablo	94806-1582
Graciela	Alderette	Fresno	93726-4447
Frances	Alet	Calabasas	91302-3408
Zsanine	Alexander	Burbank	91504-2702
Elaine	Alfaro	Felton	95018-9637
Alice	Alford	Blythe	92226-2323
Julie	Alicea	Denair	95316
Ann	Allen	San Rafael	94903-1226
Michael	Allen	Santa Barbara	93105-3036
Gail	Allen	San Francisco	94121-1829
Charles	Almack	Coronado	92118-1435
Thea	Altman	Santa Barbara	93105-4204
Melissa	Alvarado	Van Nuys	91407
Elena	Alvarez	Sacramento	95838-3343
Staci	Alziebler-Perkins	Monterey	93940-1703
Celeste	Anacker	Santa Barbara	93105-3024
Chris	Anamerican	Santa Rosa	95404-4959

Kristine	Andarmani	Saratoga	95070-3329
Jon	Anderholm	Cazadero	95421
Amy	Andersen	Lancaster	93536-4333
Patricia	Andersen	Felton	95018
Evette	Andersen	Grass Valley	95945-4813
Gretchen	Anderson	San Francisco	94118-2859
Nicole	Anderson	San Diego	92120-1335
Jeanne	Anderson	Redding	96001-4347
Eleanor	Anderson-Miles	Topanga	90290-4435
Thomas	Andrae	Berkeley	94703-1210
Leticia	Andreas	Richmond	94804-5732
S.	Andregg	Emeryville	94608
Leslie	Andrews	Santa Cruz	95060-5003
J.L.	Andrews	Elk Grove	95758-6092
Christine	Angeles	Burlingame	94010-5667
JL	Angell	Rescue	95672-9411
Bob	Anido	San Jose	95134-1613
Tina	Ann	Bolinas	94924-0265
Marie	Anthony	Palo Alto	94303
Judith	Antin	Sherman Oaks	91423-4402
Leslie	Antonio	Los Angeles	90027-3966
Patricia	Appel	Laguna Beach	92651-2842
Robert	Applebaum	San Jose	95135-1424
Marylucia	Arace	Oceanside	92057-8614
Marybeth	Arago	Fort Bragg	95437-8245
Bonnie	Arbuckle	Riverbank	95367-9608
Carol	Archer	Redondo Beach	90277-2935
Ingrid	Archibald	Woodland Hills	91367-3022
Mark	Armen	Santa Ana	92705-2967
Elisabeth	Armendarez	Santa Ana	92703-2150
Jeff	Arnett	Santa Cruz	95060-3648
Carlos	Arnold	Santa Maria	93455
Jennifer	Arnold	Los Angeles	90015-1446
John	Arns	San Francisco	94110
Reevyn	Aronson	Redwood City	94061
Vance	Arquilla	Santa Monica	90405-5311
Mary	Arreola	Los Angeles	90042-3147
Alejandro	Artigas	Los Angeles	90029-3107
Andarin	Arvola	Fort Bragg	95437-0976
Sharlene	Aschauer	Roseville	95747-8961
Heidi	Ash	Watsonville	95076-9632
Meredith	Asher	San Leandro	94578-3506
John	Astaunda	San Diego	92129-3016
Tom	Atha	Alhambra	91801-3278
Jay	Atkinson	El Sobrante	94803
Martha	Aubin	Santa Barbara	93109

Colleen	Auernig	Folsom	95630-2005
Jane	August	Topanga	90290-0666
Trina	Aurin	Foothill Ranch	92610-2305
Carl	Austin	Garden Valley	95633-0536
Joshua	Auth	Lake Arrowhead	92352-1732
Cyrille	Autin	San Diego	92108-3319
J.T.	Averre	San Jose	95124-1442
Pamela	Avnaim	Irvine	92603
Arielle	Axt	Long Beach	90815-3046
Shirley	Azevedo	Reedley	93654-7005
Jim	Baak	Martinez	94553-3550
Lisa	Babbity	Lake Forest	92630
Christina	Babst	West Hollywood	90069-5525
Tanya	Baccarat	Petaluma	94952-2643
Lois	Bacon	Freedom	95019-0007
Ellen	Baer	Riverside	92514-4411
Cynthia	Baer	Encino	91436
Rosa	Baeza	Reseda	91335-3627
Aaron	Bagheri	Goleta	93117
Richard	Bagley	San Jose	95124-6060
Carolina	Bagnarol	Redwood City	94064-1120
Thomas	Baker	San Diego	92109-2301
Sara	Bakker	Denair	95316
Steven	Bal	San Diego	92108-1179
Juan and Maria	Balboa	San Jacinto	92583-2850
Barbara	Baldock	Monterey	93940-4922
Venita	Baldwin	El Dorado Hills	95762-3513
Josephine	Baldwin	La Mesa	91941-7212
Marsha	Balian	Oakland	94618-1504
Pamela	Ball	San Leandro	94577-4903
Jeff	Ballinger, MD	Sacramento	95825
Barbara	Ballinger, Md	Menlo Park	94025-4423
Carol	Banever	Los Angeles	90046-6608
Betty	Banham	Willits	95490-8037
Walter John	Bankovitch	Berkeley	94703-1601
Alexander	Banuelos	Buena Park	90620
Elizabeth	Baptista	San Pablo	94806-5029
Soraya	Barabi	Los Angeles	90025-1351
Graciela	Barajas	San Diego	92102
Bernadette	Barberini	Alameda	94501-2341
Michelle	Barbour	Agoura Hills	91301-2450
Anne	Barker	San Rafael	94903-2446
Scott	Barlow	Sunnyvale	94087-4456
Corey	Barnes	San Rafael	94903-2853
Joanne	Barnes	Palo Alto	94306-2617
Michael	Barnes	Carlsbad	92011-3966

Jason	Barnett	San Diego	92101-3426
Anne	Barr	Greenbrae	94904-2827
Keiko	Barrett	National City	91950-8229
Susan	Barrett	San Mateo	94402-2008
Val	Barri	Beverly Hills	90210-4303
Tim	Barrington	San Jose	95112-5237
Alfredo	Barroso	San Diego	92117-3543
Marion	Barry	Loomis	95650-8875
S	Barryte	Rancho Palos Verdes	90275-2955
Janice	Bartlett	San Diego	92122-2844
Ray	Bartlett	Fountain Valley	92708-5326
Jana	Bascue	Los Banos	93635
N. J.	Bast	Morro Bay	93442-2611
Gerri	Battistessa	Petaluma	94952-4115
Mijanou	Bauchau	Agoura Hills	91301-2928
Miriam	Baum	Rancho Cucamonga	91701-3111
Gary	Baxel	Cathedral City	92234-3861
Susannah	Baxendale	Culver City	90232-3437
Jo	Baxter	Laguna Beach	92651-3212
Kathleen	Baxter	Oakland	94618
Mary	Baynard	Auburn	95602-7817
Jon	Bazinet	Vallejo	94591-7259
Heidi	Bean	Corona	92879
Grace	Bean	San Diego	92128
Dale	Beasley	Visalia	93291-9218
Janet Lee	Beatty	San Luis Obispo	93401-3702
Catherine	Beauchamp	Pasadena	91103-2052
P	Beck	Sacramento	95864-5241
Erin	Beck	Sacramento	95814-1237
Gary	Beckerman	Santa Ynez	93460-9615
Pauline	Bedford	Joshua Tree	92252-2754
Victoria	Behar	Thousand Oaks	91360-7038
Heidi	Behnke	Spring Valley	91977-2819
Richard	Behymer	Sacramento	95817
Amira	Belhedi	Rancho Palos Verdes	90275
Kimberly	Beliveau	Vallejo	94589-2528
Ana	Belle	Santa Clara	95051
Michael	Belli	South San Francisco	94080-4230
Lindsey	Belz	Cardiff By The Sea	92007-0495
Georgia	Bence	Monterey	93940-2541
Pegalee	Benda	Sonoma	95476-5407
Matt	Bender	Cardiff By The Sea	92007-1343
Gary	Bender	Huntington Beach	92646-4751
Mercedes	Benet	Carlsbad	92009
Elaine	Benjamin	Alpine	91901-2240
Maris	Bennett	Antioch	94509-5720

Debbie	Bennett	Elk Grove	95624-2627
Jeff	Bennett	Beverly Hills	90211
Beth	Bennion	Mckinleyville	95519-3561
Allison	Benoit	Gonzales	93926-0576
Julia	Benson	Oakland	94602-1112
Annette	Benton	Pittsburg	94565-7032
Suzanne	Benton	Toluca Lake	91602
Myra	Berario	Castaic	91384
Robert	Berend	Fresno	93726-4439
Karen	Berger	Montrose	91020-1284
Elmer	Berger	San Rafael	94901-5101
Peggy	Berger	Richmond	94805-1558
Colleen	Bergh	Santa Ana	92704
Lynda	Berkhan	San Clemente	92672
Susanne	Berntsson	Eastvale	92880-8919
Kelly	Berry	San Rafael	94903
John	Bertaina	San Jose	95139-1501
Craig	Bettencourt	Seaside	93955-0637
Mark	Betti	Sherman Oaks	91423-4530
Alisha	Bettinsoli	Reedley	93654
Samantha	Beumaher	Lakeside	92040-5000
Louise	Bianco	Los Angeles	91356
Nicole	Bickel	Stockton	95215-9604
Jane	Bidinian	Cool	95614-0627
Jane	Biggins	Ukiah	95482-4521
Nancy	Biggins	Ukiah	95482-4521
Valerie	Bilbo	Pauma Valley	92061-1492
Kathy	Bilicke	Los Angeles	90069-1344
Eileen	Bill	Santa Rosa	95405-4755
Barbara	Bills	Placerville	95667
Sharon	Bills	Van Nuys	91406-3615
Janet	Bindas	Walnut Creek	94598-3844
Benjamin	Bingaman	San Jose	95138-2600
Elaine	Bitzel	San Francisco	94114-2715
Douglas	Black	Dana Point	92629
Robert	Blackey	Claremont	91711-2838
Richard	Blain	Temecula	92592
Elke	Blair	Folsom	95630
Anne	Blandin	Rancho Murieta	95683-9534
Russell	Blandino	Burbank	91506-2743
Gail	Blank	Oakhurst	93644-9529
Diana	Blanks	San Diego	92116-1712
Natalie	Blasco	Anderson	96007-8901
Amanda	Blatchford	Pleasant Hill	94523-1509
Mignonette	Blazek	Felton	95018-9638
Patricia	Bleha	Carlsbad	92009

Patricia	Blevins	San Jose	95118-1808
Judith	Blick	Delmar	92014
Waundra	Blizzeard	Alturas	96101-3024
Clare	Block	San Diego	92130-6752
Martin	Bloom	San Francisco	94132-2233
Joseph	Blum	San Francisco	94110-5209
Richard	Bockover	Capitola	95010-2644
Peter	Bodlaender	Los Angeles	90039-3034
Lorraine	Bogaards	Pasadena	91105
Susan	Bogdanovich	San Pedro	90732-3313
Ronald	Bogin	El Cerrito	94530-1424
Constantine	Bogios	Walnut Creek	94597-7822
Diana	Bohn	Berkeley	94707-1726
Julie	Bohnet	Willits	95490-7721
Kathie	Boley	Three Rivers	93271
Maryann	Bomarito	Marina	93933-2611
Patrick	Bon	Simi Valley	93063-3566
Eduardo	Bonilla	Burbank	91504-3682
Martha	Booz	El Sobrante	94803-3118
Michael	Bordenave	Fresno	93728-2941
Deborah	Bortot	Fontana	92335-3811
Carol	Bostick	Novato	94949-5046
Vic	Bostock	Altadena	91001-1819
Eileen	Bostwick	Ukiah	95482-6828
Simone	Boudriot	Tujunga	91042
Shawn-Marie	Bowker	Oroville	95966-6972
Kerry	Boyd	Redwood City	94062
Ernest	Boyd	Sunnyvale	94087-2711
Gloria	Boyd	Atascadero	93422
Kerry	Boyd	Redwood City	94062-2039
Rebecca	Boyer	El Sobrante	94803-2760
David	Boyer	Palo Alto	94304-2418
Anna	Boyiazis	Los Angeles	90045-3421
Lesley	Boyland	Palos Verdes Peninsula	90274-3964
Lynne	Boynton	Corte Madera	94925-1002
Taryn	Braband	Agoura	91301-2937
Mary Ellen	Braden	Glendale	91208-1930
Jennifer	Bradford	Spring Valley	91977-3325
Peg	Bradley	Riverside	92506-4443
Tim	Brady	Aliso Viejo	92656-2849
Leslie	Branco	Visalia	93277-9166
Sean	Brandlin	Los Angeles	90094
Victoria	Brandon	Northridge	91325-2407
Sara	Brandon	Oakland	94610-3913
Dwight	Branscombe	Fort Bragg	95437-8422

Jack	Branson	Sacramento	95818-4309
Kevin	Branstetter	Applegate	95703-0383
Karen	Brant	San Francisco	94117-4320
Eric	Bratcher	Rocklin	95765
Michael	Braude	Menlo Park	94025-6003
Lisa	Braun-Glazer	La Jolla	92037-5214
Lina	Braunstein	Sacramento	95818-2121
Colleena	Brazen	Walnut Creek	94598-1728
Chris	Brazis	San Francisco	94110-5805
Gayle	Brennan	Woodland Hills	91367
Brien	Brennan	Red Bluff	96080-9591
Rosalind	Bresnahan	San Bernardino	92405-2318
Georgia	Brewer	Sherman Oaks	91401
Tania	Bride	Los Angeles	90046-4028
Sharon	Bridgforth	Los Angeles	90008
Wm	Briggs	Hermosa Beach	90254-2804
Susan	Briggs	Santa Rosa	95404-5055
Emma	Briggs	Mission Viejo	92692
Jon	Brininger	La Mesa	91942-2243
Myrna	Britton	Santa Cruz	95064-1065
Joanne	Britton	San Diego	92115-4201
Blaise	Brockman	Arcadia	91007-6917
Kerstin	Bromander	Concord	94519-1224
Zach	Bromberg	West Hollywood	90046-6507
Mary	Brooks	Frazier Park	93225-9611
Linda	Brophy	Santa Barbara	93105-3820
Ed	Brounstein	Vallejo	94589-1954
James	Brown	Los Angeles	90034
Damon	Brown	Los Angeles	90016-5229
Mary Ett	Brown	Cambria	93428-4501
Kimberly	Brown	Pacific Grove	93950
Debrah	Brown	Beaumont	92223-3106
Meg	Brown	New Cuyama	93254-0125
Jeannine	Brown	Vallejo	94591-4202
Amy Jo	Brown	San Francisco	94118-4433
Robin	Brown	Dana Point	92629
Mary	Brown	Chico	95928-5649
Saren	Brown	Santa Barbara	93103-2135
Patricia	Brown	Loomis	95650-9448
Jack	Brown	Capistrano Beach	92624
Rj	Browne	Weed	96094
Carol	Browning	Camarillo	93011
Nick	Bruce	Glendora	91740-6123
Fritz	Brunner	Walnut Creek	94598-3121
Nancy	Bruno	San Luis Obispo	93401-5676
Ray	Bruz	Newport Beach	92659

Lauren	Bryant	La Crescenta	91214-1323
Theresa	Bucher	Tarzana	91356-3220
Leo	Buckley	San Francisco	94110-1222
George	Budd	Los Angeles	90035-3506
Zach	Bue	Los Angeles	90019
Joe	Buhowsky	San Ramon	94582-4865
Tammy	Bullock	El Cajon	92021-2904
Sarah	Bulock	West Hills	91304
Valerie	Bump	Fallbrook	92088
Sharon	Bunch	Piedmont	94611-4419
Bitsa	Burger	Novato	94947
Kat	Burgess	Santa Monica	90404-7121
Holly	Burgin	Van Nuys	91405-1435
Robert	Burk	Los Angeles	90024-2544
Caitlin	Burk	Bodfish	93205-9534
Kelly	Burke	Carmel	93921
Robert	Burkowski	North Hollywood	91606-2727
George	Burnash	Rancho Cordova	95670-3637
Peggy	Burns	Rowland Heights	91748-4718
Mary	Burns	Chino Hills	91709-2320
David	Burtis	Calistoga	94515-9785
Edward	Burtner	Forestville	95436-9208
Andrea	Bustos	Trinidad	95570-0339
Simone	Butler	San Diego	92110-2146
Katherine	Butler	Santa Cruz	95065-9686
Sam	Butler	Los Angeles	90045-2753
Nancy	Byers	Berkeley	94703-2518
Sharon	Byers	Dowmey	90242
Charles	Byrne	San Francisco	94115-2518
Rebecca	Cadman	Santa Cruz	95062-2112
Mike	Caetano	Fresno	93704-2920
Tamara	Cain	Sacramento	95826-5202
Maureen	Cairns	Studio City	91604-3076
Dennis	Cajas	Apple Valley	92308-8445
Kyle	Calcagno	Huntington Beach	92649-3615
Jesse	Calderon	Baldwin Park	91706-4431
Paul	Callaghan	Auburn	95603-4423
Tyler	Callahan	Alameda	94501
Cl	Callahan	Chico	95926-3948
Danielle	Cambier	San Francisco	94131-3122
Luis	Camero	Santa Clarita	91390-4619
Laurel	Cameron	Redondo Beach	90277-4827
Sharon	Camhi	Petaluma	94952-3282
Lynn	Camhi	Petaluma	94952-6446
Gail	Camhi	Novato	94949-6804
David	Camp	Burbank	91501

Dudley and Candace	Campbell	Van Nuys	91401-1329
Allan	Campbell	San Jose	95132-1920
Mark	Campbell	Los Angeles	90004
Robert	Candelaria	Summerland	93067
Sylvia	Cardella	Hydesville	95547
Tiffany	Carder	Huntington Beach	92646-4217
Rebecca	Carey	Santa Maria	93454-1567
Shelley	Carlisle	Novato	94947-2092
David	Carlson	West Hollywood	90069-1501
Rita	Carlson	Eureka	95502-3753
Judy	Carlson	Newport Beach	92660-7359
Susan	Carlson	Davis	95616-5621
David	Carlson	San Francisco	94122
Karen	Carlson	La Jolla	92037-7154
Sharon	Carlson	Woodland Hills	91364
Chris	Caron	Pasadena	91104-4243
Caryl	Carr	Palo Alto	94301
Paula	Carrier	San Diego	92101-1674
Greta	Carrillo	National City	91950
Suellen	Carroll	Garden Valley	95633-9477
Kelley	Carroll	Truckee	96161-1335
Dr. Viviane	Carson	Palmdale	93550-4723
Carl	Cartwright	Whittier	90605-3333
Jennifer	Cartwright	San Clemente	92673-3532
Suzanne	Caruso	Davis	95616
Georgia	Carver	Rancho Cordova	95670-3636
Federico	Casagran	Los Angeles	90065-5138
Regina	Case	Eureka	95503-5850
Lisa	Caserma	San Pedro	90731-4538
Stewart	Casey	Garden Grove	92841-4638
Kristen	Cashman	Novato	94949-6392
Stella	Casillas	Santa Cruz	95062
Mike	Cass	Novato	94947-4766
Robert	Cassinelli	Sacramento	95821-3817
Michele	Castano	Brentwood	94513-5663
Vicky	Castellanos	Coronado	92178
Joseph	Catania	Fresno	93728-1522
Paula	Cavagnaro	Livermore	94550-3403
Edward	Cavasian	Palo Alto	94303-3409
Gwen	Cavazos	Squaw Valley	93675-9351
Judy	Cawley	Huntington Beach	92646
Emilio	Ceballos	Bakersfield	93305-4519
Jayne	Cerny	Inverness	94937-0241
Carina	Chadwick	Los Angeles	90019
Holly	Chadwin	Santa Barbara	93110-1470

Beverly	Chan	Diablo	94528
Alice	Chan	Los Angeles	90016
Brendan	Chan	Redwood City	94063-5735
Herman	Chaney	Oakland	94612-4052
Elizabeth	Chang	Santa Monica	90401
Sharon	Chang	Clearlake Oaks	95423-9567
Cherie	Chantal	Moorpark	93021-3323
S.	Chapek	San Francisco	94118-2520
Lois	Chappell	San Diego	92110-1130
John	Charbonneau	Spring Valley	91977-4456
Stacie	Charlebois	Sebastopol	95472-2928
Anik	Charron	Marina Del Rey	90292-5639
Felicia	Chase Zeff	Woodland Hills	91364-4925
Cindy	Chatham	Lakeport	95453
Yvonne	Chavez	Carlsbad	92008
Joyce	Chavez	San Diego	92123-2551
Melvin D.	Cheitlin	San Francisco	94109-0427
Johan	Chen	Walnut	91789
Robin	Cheney	San Clemente	92672-4058
Elizabeth	Chenoweth	Rancho Santa Fe	92067
Justin	Chernow	Paso Robles	93446-4834
Russell	Cherry	Placerville	95667-8309
Antonia	Chianis	Blue Jay	92317-0836
Deborah Lee	Chill	Yucaipa	92399-5351
Michael	Chin	South San Francisco	94080-5333
Karen	Chinn	Cloverdale	95425-5457
Robert	Chirpin	Northridge	91324
Albert	Chiu	Oakland	94611-1542
Greta	Choa	Commerce	90040-2115
Ana	Chou	Palo Alto	94306-2944
Kathryn	Choudhury	Moraga	94556
Sandra	Christopher	Burbank	91505-1856
Thane	Christopher	Burbank	91522-0001
William	Christwitz	Clearlake	95422
Jonathan	Chu	Fremont	94539-4440
Christina	Ciesla	Simi Valley	93063-0214
Melinda	Cisneros	Long Beach	90805-4334
Jan	Civil	Stockton	95202
Patricia	Clancy	Goleta	93117
John	Clark	San Diego	92101
Stephanie	Clark	Pleasant Hill	94523
Jd	Clark	Petaluma	94954-1598
Amelia	Clark	La Mesa	91941-5766
Robin	Clark	Mission Viejo	92692-4213
Sharon	Clark	Novato	94949
Heidi	Clarke	Reseda	91335-3730

Mark	Clearwater	Oakland	94618-2410
Brittany	Clemens	Huntington Beach	92648-8306
Kathy	Clements	Orange	92867-5846
Britt	Clemm	Santa Clara	95051-3958
Ruth	Clifford	San Jose	95126-4135
Luana	Clme	Moreno Valley	92557-5014
Jim	Clough	Glendale	91204-1154
Mike	Cluster	Concord	94520-1560
Scott	Coahran	Los Banos	93635-4055
Shane	Coburn	Los Angeles	90066-4801
Sandra	Coca	Orangevale	95662
Jean	Cochran	Pomona	91767-2075
Jacqueline	Cochrane	Redondo Beach	90278-2045
Shirley	Cofresi	Applegate	95703-8801
Margaret	Cohea	El Cerito	94530
Asher	Cohen	Los Altos	94024-7214
Charlotte	Cohen	Palm Desert	92260
Andy	Cohen	Los Angeles	90049-3310
Tina	Colafranceschi	Whitethorn	95589-0201
Karen	Colbourn	Sacramento	95827-3501
Diana	Cole	Oceanside	92057-1955
John	Cole	Hollister	95023
Mary	Coleman	Orangevale	95662
David	Coleman	Cobb	95426-1321
Cayla	Coleman	San Rafael	94901
Emily	Coles	San Francisco	94114-2713
Cynthia	Coley	Lake Forest	92630-2607
Mark	Coller	Shasta Lake	96019-2291
William	Collier-Byrd	Redwood City	94063
Laura	Collins	Rancho Cordova	95670-3551
Geoffrey	Collins	Garden Grove	92845-1521
Deborah	Collodel	Malibu	90265-4625
Clare	Colquitt	San Diego	92116
Britt	Colton	San Diego	92116-1646
Mr. and Mrs.	Colvin	San Francisco	94105-2245
Glen	Colwell	Arcata	95521
Sharon	Colyar	Clovis	93612
Gina	Comin	Santa Barbara	93102-0746
Denise	Comiskey	Mckinleyville	95519-3383
Sandy	Commons	Sacramento	95821
Carla	Compton	Placerville	95667-7009
Bree	Condon	Venice	90292
Jasmine	Congdon-Ng	Hermosa Beach	90254-2318
Steven	Coniglio	Truckee	96161
Gary	Connaught	Shasta Lake	96019-9718
Carrie	Conrad	Sanger	93657

Thomas	Conroy	Manhattan Beach	90266
Susan	Considine	Los Angeles	90019
Ruth	Consul	Palo Alto	94306-1245
Carol	Cook	San Mateo	94403-5015
Rebeccah	Cook	American Canyon	94503
Michael	Cooper	Santa Cruz	95060-9695
Andras	Cope	Irvine	92612-8621
A	Corbet	Oakland	94610-0567
Andrã©S	Corchs	Beverly Hills	90210
Aida	Cordero	Santa Barbara	93111-2122
Anna	Cordova	Santa Maria	93458-1400
Dakota	Corey	Ventura	93003-6734
Rodney	Cornelius	Sacramento	95833-1816
Alyza	Cornett	Los Angeles	90056
Alyza	Cornett	Los Angeles	90056-1038
Hana	Correa	La Quinta	92253-3691
Melanie	Corrigall	Walnut	91789
Jennifer	Corrigan	Newbury Park	91320
Ronit	Corry	Santa Barbara	93101
Erlinda	Cortez	Long Beach	90807-1808
E	Cotton	Encinitas	92024-4043
Eric	Coulson	Sunnyvale	94086
Ms	Courtney	Orange	92867-6214
Paola	Covarrubias	Coronado	92118
Sandi	Covell	San Francisco	94112-1401
Colin	Coward	Baldwin Park	91706-4551
Jenn	Cox	Carmichael	95608
Jamie	Cox	Rocklin	95765-5165
Leslie	Cozad	Cotati	94931-5362
John	Crahan	Los Angeles	90045-3731
Michael	Craib	Watsonville	95076-4020
Lil	Craig	Anaheim	92804-6418
Donna	Crane	Anderson	96007-3245
Mark	Crane	Los Angeles	90068-2661
Steve	Crase	Antioch	94509-1843
Sheilagh	Creighton	Fairfax	94930-1525
Cathy	Cretser	Vacaville	95688-9639
Judy	Cribbins	Nevada City	95959-9304
William	Crist	Pacifica	94044-2803
Nanette	Cronk	Truckee	96161-4923
Charley	Cross	Sacramento	95831
Jeff	Crossley	Carmichael	95608-2191
Anne	Crossway	Placerville	95667-9413
Anabel	Crouch	Elk Grove	95758-3903
Rupica	Crowder	Altadena	91001
Jesse	Croxton	Venice	90291-2806

Cathy	Crum	Agoura Hills	91301-3508
Marian	Cruz	Merced	95348
Tara	Cufaude	Sacramento	95819
Kermit	Cuff	Mountain View	94041-1160
Jon	Culbertson	San Rafael	94901-1787
Sherrell	Cuneo	Los Angeles	90027-1053
Debra	Cunningham	Carlsbad	92008-1914
Barbara	Cunningham	Glendale	91205-4409
Katelyn	Cunningham	Glendale	91208-1006
Barbette	Curran	Laguna Woods	92637-2763
Chris	Curtis	Los Angeles	90026-3118
Richmond	Curtiss	Palm Springs	92264-7213
Tim	Custis	Sunnyvale	94086-1738
Romona	Czichos-Slaughter	Hollister	95023-6720
Carole	Dadurka	San Clemente	92673-2705
Carmel	Dagan	Los Angeles	90048-4817
Bill	Dake	South San Francisco	94080-1612
Lillian	Dakouris	San Diego	92130-1847
Donald	Dales	Fallbrook	92028-2525
Rev Dr Donald J	Dallmann	Cambria	93428
Dory	Dallugge	Thousand Oaks	91362-2141
Shane	Daly	Sun Valley	91352-3461
Krista	Dana	Sunnyvale	94087-2241
Nancy J	Danard	Berkeley	94703-1884
Lisa	Dancel	Hesperia	92345-3960
Erin	Daniels	Carson	90746-2618
Pat	Daniels	Spring Valley	91977-1123
Alisa	Danyeur	Benicia	94510-1625
Jessica	Dardarian	Sherman Oaks	91403-3493
Kimble	Darlington	Smith River	95567-9536
Elizabeth	Darovic	Monterey	93940-1909
Sarah	Date	Healdsburg	95448
Susan	Davenport	Simi Valley	93063
Bob	Davey	Laguna Beach	92651
Dorothy	Davies	San Francisco	94114-2324
Sha	Davies	Redding	96001-3827
Jill	Davine	Culver City	90232-3207
Patti	Davis	Santa Monica	90403
Ryan	Davis	Burbank	91502-1826
Timothy	Davis	Garden Grove	92845-2736
Cheryl	Davis	Rio Linda	95673-1803
Katherine	Davis	Los Angeles	90057-5508
David	Davis	Manhattan Beach	90266-4128
J	Davis	San Francisco	94102-4000
Hillary	Davis	San Rafael	94903-2885

Bob	Davis	San Diego	92116-1908
Bonny	Davis	Watsonville	95076-2427
Melinda	Davis	Anaheim	92801-4314
Lyndsay	Dawkins	Davis	95618-1531
James	Dawson	Davis	95618-6741
Connie	Day	Sacramento	95835-1740
Michele	De La Rosa	Rohnert Park	94928-8171
Sacha	De Nijs	Huntington Beach	92647-6618
Elisse	De Sio	San Carlos	94070-5009
Michele	Deady-Paano	Lakewood	90712
Rayline	Dean	Ridgecrest	93555-3622
Vic	Deangelo	San Francisco	94121-3128
Glen	Deardorff	Castro Valley	94546-2722
Janii	Dearmendi	Arroyo Grande	93420-6570
Therese	Debing	Pacific Grove	93950-2450
Yves	Decargouet	Lucerne	95458-8502
Terri	Decker	Redding	96001
Bonnie	Declark	San Rafael	94901-3433
Mary	Dederer	Menlo Park	94025
Ester	Deel	Oakland	94603-4142
Thomas	Deetz	Watsonville	95076-0507
Amy	Deguzis	Santa Monica	90405-3120
Denise	Dejesus	Sanger	93657-3336
Kiriki	Delany	Bayside	95524-9376
Donnie	Deleon	Chula Vista	91913
Arthur	Delgadillo	Long Beach	90813
Roxanne	Delgado	Antioch	94509-1852
Elizabeth	Deloughrey	Los Angeles	90066-5822
Margaret	Demott	Sacramento	95822-8309
Katherine	Den Bleyker	Los Angeles	90043-3706
Lawrence	Deng	San Jose	95120
Ashley	Deng	San Jose	95125
Marilyn	Dennis	North Hills	91343-4612
Michael	Denton	San Leandro	94578-3806
Genevieve	Deppong	Los Altos	94024-7408
Christopher	Derry	Oakland	94602
Felix	Desroches	Laguna Beach	92651
Antonio	Dettori	San Diego	92117-2501
Irene	Deutsch	San Francisco	94116-2716
Sandy	Devenport	Modesto	95356-8612
Connie	Devine	San Jose	95138-1845
David	Dexter	Mill Valley	94941-3624
Dave	Diamond	Carlsbad	92008-1452
Leilani	Dicato	Orange	92868-3925
Nancy	Dick	Richmond	94804
Lori	Dick	Claremont	91711-1431

Barbara	Diederichs	Poway	92064-5832
Steve	Dietrich	Los Angeles	90065-3933
John	Digitale	Mountain View	94040-1461
Andra	Dillard	Santa Barbara	93111-1110
Terry	Dillard	Belmont	94002-2034
Lawrence	Dillard, Jr.	San Francisco	94124-3158
Maureen	Dillon	Pacific Grove	93950-4006
Howard	Dillon	Bolinas	94924-9776
Dominic	Dimaio	Millbrae	94030-1853
Greg	Dinger	Mount Shasta	96067
Laura	Divenere	Los Angeles	90020-4609
Andrea	Dixon	Redlands	92373
Mary K	Doane	Watsonville	95076-0320
Timothy	Dobbins	San Francisco	94117-3048
Jennice	Dobroszczyk	Clovis	93612
Irene	Dobrzanski	Arcadia	91066-0537
Rachel	Docherty	Boyes Hot Springs	95416-1613
James	Dodd	Guerneville	95446-1226
David	Doering	San Francisco	94109-3607
Joanne	Doherty	Simi Valley	93065
Renate	Dolin	Malibu	90265-5347
Doreen	Domb	Grass Valley	95945
Mari	Dominguez	Linden	95236-9419
Britton	Donaldson	San Diego	92103-2928
Stephen	Dondershine	Burlingame	94010-3021
Michael	Donnelly	Cameron Park	95682
Mary	Donnelly	Cameron Park	95682
Joan	Donovan	San Mateo	94403-4567
Dawna	Dorcas-Werner	Yucaipa	92399-9758
LL	Dored	Los Angeles	90046-1420
Jeff	Dorer	Los Angeles	90057-1826
Michael	Dorer	Fremont	94538-1248
Gale	Dorion	Los Angeles	90068
Pamela	Dornfeld	Bodega Bay	949233-9718
Ann	Dorsey	Northridge	91325-3844
Lyn	Doster	Northridge	91324
Dennis	Dougherty	San Rafael	94903-3095
Paulette	Doulatshahi	Playa Del Rey	90293
Shana	Doverspike	Bakersfield	93307-3031
Dawn	Dowdy	Visalia	93277-7075
Holly	Dowling	Pope Valley	94567-0026
Steve	Downing	Santa Barbara	93109-1923
Gwyn	Drischell	Tujunga	91042-2939
Mary	Driskill	Mission Viejo	92692-1863
Dale	Drouin	Walnut Creek	94596-3372
Anna	Drummond	Grass Valley	95945-3303

Bob	Druwing	Van Nuys	91401-1029
Terry	D'Selkie	Ukiah	95482
Philip	Dubrow	San Francisco	94104-3301
Esther	Duck	Beverly Hills	90212-4713
Monica	Duclaud	San Francisco	94107
Cynthia	Dudley	Escondido	92025
B	Dudney, Md	Forestville	95436
Glenda	Dugan	Walnut Creek	94598-3129
Tan	Dugi	Los Angeles	90033
Ernest	Dun	Oceanside	92057-1943
Diana	Duncan	Santa Monica	90403-1625
Janis	Duncan	Ventura	93003-3959
Kelly	Dunn	Manhattan Beach	90266-3451
Tracy	Dunn	Rohnert Park	94928
Greg	Dunnington	San Jose	95133-1762
Arnaud	Dunoyer	Venice	90291-3836
Nicolas	Duon	Santa Ana	92705-5812
Nick	Duon	Santa Ana	92705-5812
Judith	Dupree	Pine Valley	91962-0365
Kira	Durbin	Sherman Oaks	914113712
Melissa	Durkin	Gilroy	95020-4923
Carolyn	Duryea	Saint Helena	94574-1773
Derek	Duszynski	Sacramento	95834-3851
Ruth	Duvalle	Chico	95973-9297
Alan	Dwillis	Lathrop	95330-9396
William	E. Watkins	Vista	92085-2345
Anne	Earhart	Laguna Beach	92651-1547
Emily	Earl	Berkeley	94703-2006
Shinann	Earnshaw	Fortuna	95540
Joan	Easterday	Santa Rosa	95404
Carol	Easton	Aptos	95003-9762
Austin	Eastridge Junior	Felton	95018-0952
Chris	Eaton	Tujunga	91042-1836
Andres	Echeverria	Culver City	90232-3119
Jerry	Eckel	Granada Hills	91344
Elaine	Edell	Malibu	90265-5125
Paul	Edelman	Woodland Hills	91364-3313
Jonathan	Eden	Berkeley	94707
Glory	Eden	El Dorado	95623
Yvonne	Eder	Tracy	95376-3226
Emily	Edmond	Sacramento	9-5814
Rick	Edmondson	Danville	94526-3934
Jane	Edwards	La Palma	90623-1640
Susie	Egan	San Diego	92163-1864
Gretchen	Egen	Martinez	94553-3052
Rachel	Egerton	Trabuco Canyon	92679-3406

Rebecca	Egger	Berkeley	94705-2739
F. R.	Eguren	Hermosa Beach	90254-4210
Vivian	Ehresman	Chatsworth	91311-2441
Anett	Eichler	Portola	96122-0445
Elizabeth	Eisenbeis	Lodi	95242-3732
Angela	Eisentrout-Melton	Orangevale	95662
Rich	Elam	San Diego	92117
Susan	Elliott	Concord	94521
Koll	Ellis	Kensington	94707
Caleb	Ellis	Los Angeles	90046-2828
Norm	Ellis	Corona Del Mar	92625-2025
James	Ellison	Redondo Beach	90278-1719
Dave	Elmore	Bonita	91902-2537
Lora	Elstad Bello	Los Angeles	90065-2049
Bonnie	Elsten	Long Beach	90803-2201
Angela	Embree	Oxnard	93036-1519
C	Emerson	Sacramento	95816-6114
Susan	Emerson	El Cajon	92021-2577
Laurel	Emsley	Carmel	93923-9739
Brent	Endicott	San Diego	92128-7203
John	Engell	San Francisco	94102-3200
Helen	Engledow	Sonora	95370-6201
Teresa	English	Los Angeles	90068
Karen	English	Citrus Heights	95621-5575
Walter	Erhorn	Spring Valley	91979-1843
David	Erickson	Cupertino	95014
Carolyn	Erskine	Berkeley	94707-2727
Kathleen	Ervin	San Diego	92117
Kelly	Erwin	Cathedral City	92234-3446
Brenda	Escobar	Santa Cruz	95065-1846
Louise	Espinoza	Santa Rosa	95407-7655
Dan	Esposito	Manhattan Beach	90266-4082
Isabel	Esquivias	Morgan Hill	95037
Nicholas	Esser	Simi Valley	93065
Michael	Essex	El Dorado Hills	95762
Noah	Evans	Mill Valley	94941-3440
Kersti	Evans	Sacramento	95822-1657
Bill	Evans	Pasadena	91104-3025
Ramona	Evans	Long Beach	90806-6948
Pam	Evans	Garden Valley	95633-9439
John	Everett	Grass Valley	95945-4156
Tim	Ewing	Monterey	93940-1163
Heather	Fadden	Santa Rosa	95403-4134
Cecelia	Faigin	Granada Hills	91344-5754
David R	Fair Sr	Santa Ana	92799

Peter	Fairley	Kings Beach	96143-4504
Dominick	Falzone	Los Angeles	90005-2060
Marie	Famnin-Laird	Granite Bay	95746
Valerie	Fannin	Chico	95973-8759
Maryam	Faresh	Toluca Lake	91610
Amy	Farrell	West Hollywood	90069
Timothy	Farrell	San Francisco	94132
Kelly	Farrens	Carmichael	95608
David	Farwell	Carmel	93923
Ffa	Fdsaf	El Cajon	92020-3909
Mary	Fedullo	San Jose	95123-5001
Kathrine	Fegette	Newcastle	95658-9740
Daniel	Fehr	Redding	96001-1118
James	Feichtl	Belmont	94002
Marla	Feierabend	Santa Barbara	93109-1835
John	Feissel	Cotati	94931-9652
Jo	Feldman	Malibu	90265-4247
Mark	Feldman	Santa Rosa	95401-9137
R.	Felice	San Diego	92106-2743
Ashley	Felix	Riverside	92506-5654
Ruth	Felix	Walnut Creek	94597-3925
Jon	Fell	Hayward	94542-7912
Haydee	Felsovanyi	Pescadero	94060
Cindy	Ferguson	Sacramento	95827-3275
Neil	Ferguson	Vacaville	95688-9223
Michael	Ferris	Long Beach	90808-4038
Thomas	Ferrito	Los Gatos	95030
Richard	Ferry	San Jose	95112-1911
Asano	Fertig	Berkeley	94702-1427
Neal	Feuerman	Hydesville	95547-9407
Susan	Fiedler	Rescue	95672-0220
David	Field	Santa Cruz	95060
Aixa	Fielder	Los Angeles	90028-5764
Heidi	Fielding	North Hollywood	91606-2276
Gloria	Figg	Long Beach	90805-1422
Chris	Figueroa	Monrovia	91016
Jose	Figueroa Jr	Fremont	94536-5021
Thomas	Filip	Moorpark	93020-1332
Cynthia	Fillmore	La Mesa	91942
Jason	Fish	Fair Oaks	95628
Larry	Fish	Riverside	92501-3941
Melanie	Fisher	Calabasas	91302-3073
Juels	Fisher	Chino Hills	91709
Cay	Fisher	Penn Valley	95946
Bob	Fisher	Laguna Hills	92654-2730
Ted	Fishman	San Jose	95123-2639

Todd	Fisk	San Diego	92131-3573
Kevin	Fistanic	Los Angeles	90066-6753
Gregory	Fite	Hayward	94541
Cay	Fitzgerald	Santa Barbara	93103
Anne	Fitzmedrud	San Pablo	94806
Don	Fitzpatrick	Ramona	92065-4342
Bob	Flagg	Forestville	95436-1591
Sara	Flamm	Los Angeles	90034-4998
Marcia	Flannery	Oakland	94609-2608
Eric	Fleming	Alta Loma	91701
Stephanie	Flesner	Long Beach	90804-5003
Claire	Flewitt	San Leandro	94579-1472
Brian	Flores	Hayward	94541
Lizabeth	Flyer	Burbank	91505-3410
Sara	Fogan	Santa Clarita	91385
Byron	Fogel	Panorama City	91402-4518
Stephan	Foley	Ojai	93023-3607
Stephen	Foltz	Aptos	95003-6012
Melanie	Fontana	San Diego	92114-1930
Jane	Forbes	Santa Cruz	95060-9776
Phyllis	Ford	Martinez	94553-3603
Erin	Foret	Martinez	94553
William	Fornaciari	San Diego	92130-1829
Patricia	Forrest	Santa Cruz	95060-6100
Hal	Forsen	San Clemente	92672-3947
Dawn	Fortis	Rancho Palos Verdes	90275-5086
Steffen	Foster	Pacific Palisades	90272-2539
Gayle	Foster	San Bernardino	92408
Janie	Fox	Alameda	94501-3717
Laurie	Fraker	El Centro	92243-2335
Darren	Frale	Los Angeles	90065-3214
Mary	Franceschini	Concord	94521-3078
Rita	Franco	Monrovia	91016
Karla	Frandson	San Diego	92128-2608
Benita	Franklin	Oakland	94612
Amy	Franz	La Habra Heights	90631-8433
Mary	Franz	Laguna Beach	92651-2816
Forest	Frasieur	Benicia	94510
Cary	Frazee	Eureka	95503-9592
Barbara	Frazer	Sacramento	95816-3937
Andreina	Frazier	San Fernando	91340-1370
Heather	Frederick	Los Angeles	90026-4317
Oceana	Free	San Diego	92107-3365
Steve	Freedman	Marina Del Rey	90292-5515
Rea	Freedom	Los Gatos	95033-8840
Jenny	Freeman	El Cerrito	94530-3302

Linda	Freeman	Yuba City	95991-8866
Francine	Friar	Santee	92071-4034
Maggy	Frias	San Francisco	94132
Lois	Friedland	Palm Desert	92211-5908
Leanne	Friedman	Davis	95616-0853
Michael	Friedman	El Sobrante	94803-1812
Jan	Friel	Fullerton	92831-1403
Linda	Frischer	Santa Rosa	95403
Inga	Frolova	San Francisco	94107-4119
Jeff	Fromberg	Los Angeled	90949
Lorie	Frost	Petaluma	94952
Tina	Frugoli	Thousand Oaks	91362-2630
Joyce	Frye	La Quinta	92253-8171
Lisa	Fujihara	San Jose	95125
Arlene	Fullaway	Cypress	90630-3627
Tony	Fuller	Petaluma	94954-9552
Gerald	Fuller	Mission Viejo	92691
Thomas	Fulton	Sonora	95370-9007
Carol	Fusco	Berkeley	94708-2058
Gilda	Fusilier	Sacramento	95831-1382
Sherrill	Futrell	Davis	95618-5421
Jeffrey	Fylling	Santa Fe Springs	90670-5622
Catherine	Gaehwiler	S Lake Tahoe	96150-5115
Nick	Gaetano	Laguna Beach	92651
Judith	Gage	Fort Bragg	95437
Glory	Gage	Cerritos	90703
Jerry	Gahan	Twentynine Palms	92277
Victoria	Gairaud-Hinkley	Aptos	95003-4822
Martha	Galaif	Pacific Palisades	90272-2603
Anjelina	Galbadores	Fresno	93726-2109
Barbara	Gale	Tarzana	91356-4313
Lynn	Gallagher	Santa Cruz	95062-2238
Maureen	Gallagher	Canyon Country	91387-1706
Kellie	Gallagher	Twentynine Palms	92277-0186
Nina	Gallardo	Colton	92324
Maria	Gallardo-Gower	San Marcos	92069
Rob	Gallinger	Los Angeles	90042-3228
Stella	Gamble	Pittsburg	94565-6247
Elizabeth	Gann	Lake Arrowhead	92352-3188
Lisa	Gansky	Napa	94559-2826
Angela	Gantos	Belvedere Tiburon	94920-2010
Sheila	Ganz	San Francisco	94122-2846
Sharma	Gaponoff	Grass Valley	95949
Hector	Garcia	Los Angeles	90005
Armando A.	Garcia	Perris	92571-7715
Shana	Garcia	San Dimas	91773-7115

Lita	Garcia	Los Angeles	90042-4330
Patty	Garcia	Oakland	94610-1665
Katie	Garcia	Bakersfield	93313
David	Gardner	Santa Monica	90405
Dr A	Gardner	Oakland	94602
Jamila	Garrecht	Petaluma	94952-4157
Cherie	Garrett	Santa Barbara	93103
Valerie	Garrett Miller	Los Angeles	90046-1712
Alisa	Garrison	Truckee	96162-7736
Elisabeth	Garst	Berkeley	94705-1110
J	Gary	San Diego	92103-2903
Jan	Gates	Napa	94559-9704
Nick	Gates	San Clemente	92672
Jen	Gavin	Trinidad	95570
Steffanie	Gee	Los Angeles	90064-2484
Sandra	Geist	Santa Cruz	95060-5719
Julie	Gengo	Alameda	94501-2340
Mija	Gentes	Saratoga	95070-5969
Laquita	Gentry	Lodi	95242
Catherine	George	Napa	94559-4464
Carolyn	George	Palo Alto	94306-3636
Alexis	Georgiou	Santa Clara	95054-2243
Inna	Gergel	Granada Hills	91344-3510
Phillip	Gernes	Bakersfield	93312-2422
Lisa	Gherardi	Los Gatos	95032-5422
Robert	Gibson	Livermore	94550-3935
William	Gies	Saratoga	95070
Phoenix	Giffen	Fairfax	94930-1601
Camille	Gilbert	Santa Barbara	93101
Tracy	Gilbert	Rialto	92377-8831
Kenneth	Gilchrist	Los Angeles	90026
Mary-Lou	Gillette	Fremont	94539-5253
Barbara	Ginsberg	Santa Cruz	95062-3561
Coreana	Giordano	Claremont	91711
Brian	Girard	Ventura	93004-2454
Barbara	Gladfelter	Dixon	95620-3627
Christine	Gladish	Sierra Madre	91024
Catherine	Glahn	San Mateo	94402-4029
Joe	Glaston	Desert Hot Springs	92240-9555
Maryanne	Glazar	Berkeley	94710-2050
Robert	Glover	Fresno	93726-2313
Edwin	Glover	Hacienda Heights	91745-5812
James	Goethel	San Diego	92115-2223
Gary	Goetz	Pacific Grove	93950
Warren	Gold	Mill Valley	94941-5080
Dani	Gold	Newport Coast	92657

Paula	Goldberg	Palo Alto	94301-2630
Daniel	Goldberg	Santa Cruz	95060-2734
Stephen	Golden	Hercules	94547-2212
G	Goldfarb	Malibu	90265-5359
John	Golding	Oakland	94619-1364
Jill	Goldman	Toluca Lake	91610-0032
Toni	Goldman	So. San Francisco	94080
Stuart	Goldstein	Lagunitas	94938-0082
Linda	Goldstone	San Francisco	94117-3816
Vola	Golena	Beverly Hills	90210-4256
Lindsay	Golter	Laguna Niguel	92677
Anne	Gomer	Martinez	94553
Eleanor	Gomez	San Francisco	94116
Connie	Gomez	Palmdale	93552
Robert	Gondell	Woodacre	949730
Tara	Gonzales	Atascadero	93422-4340
Bonnie	Gonzales	Costa Mesa	92626-4101
Dawn	Gonzales	Reseda	91335
Alan	Gonzalez	Long Beach	90815-0616
Jon	Goodman	West Hollywood	90069-3869
Colleen	Goodman	Los Gatos	95032-2811
James	Goodwin	Los Angeles	90068-3928
Carol	Gordon	Los Angeles	90027-1118
Viviane	Gordon	San Francisco	94114-2803
Patrick	Gorgen	Los Angeles	90034
George	Gorohoff	San Jose	95123-1445
Mark	Gotvald	Pleasant Hill	94523-2736
Crystal	Govea	Placentia	92870-3907
George	Grace	Los Angeles	90027-4720
Janet	Gradl	Torrance	90502-1421
Steve	Graff	Los Angeles	90025
Jess	Graffell	Yucaipa	92399-7025
Herb	Grageda	San Pedro	90731-6425
Randi	Graham	St Adolphe	90210
Barbara	Graham	San Diego	92110
Robin	Graham	San Francisco	94121-1004
D	Grams	Los Angeles	90039-1615
Fred	Granlund	North Hollywood	91601-1723
Gia	Granucci	Healdsburg	95448-7079
Caryn	Graves	Berkeley	94702-1329
Lorraine	Gray	Piedmont	94611
Charlotte	Gray	Hemet	92544-5236
Jamie	Green	Ventura	93004-2884
Savannah	Green	Mendocino	95460-1460
Gary	Green	Pasadena	91107
Janice	Greenberg	Berkeley	94705-1826

Stephen	Greenberg	Nevada City	95959-2856
Jeanne	Greene	Chico	95928-9468
J	Greene	Chico	95927-0125
Linda	Greene	La Habra	90631-7233
Danny	Greene	Escondido	92025-6012
Paul	Greenfield	Oakland	94607
Jerry	Greenstein	San Rafael	94901-1406
Barbara	Greenwood	Walnut Creek	94596-6127
Ms. Jared	Greer	San Pablo	94806-4885
Faye	Gregory	Colton	92324-2734
Jeffrey	Greif	Venice	90291-3871
Debi	Griepsma	Fontana	92335-5258
David	Griffith	Rancho Cucamonga	91737-3017
Melody	Grigg	Santa Maria	93455-3129
Peter	Grimm	Pasadena	91104-4731
Kelly	Grindstaff	Berkeley	94710-1845
Laure	Grinnell	Alameda	94501
Dean	Griswold	Fair Oaks	95628-2929
Alexis	Grone	Oceanside	92058-1727
Kurt	Gross	San Diego	92176-6898
Alexandra	Gross	Sherman Oaks	91423
Gloria	Grotjan	Aptos	95003-5028
Ann	Grow	Chula Vista	91910
Paul	Gruber	Berkeley	94703-1518
Vicki	Gruman	Walnut Creek	94597
Joel	Gruwell	Folsom	95630
Craig	Guenther	Lakeport	95453
Cheryl	Guerrie	Temecula	92591-1724
K	Gugeler	Sacramento	95819-3552
Eugenia	Guilin	Blythe	92225-9215
Stacy	Guillan	Oceanside	92056-2530
Sylvia	Gunning	Newbury Park	91320
J. Barry	Gurdin	San Francisco	94122-4617
Bill	Gurney	Novato	94948
Nora	Guthrie	Santa Rosa	95409-2610
Elin	Guthrie	Los Angeles	90019-2838
Nancy	Gutierrez	Palm Desert	92260-4910
Oscar	Gutierrez	Chula Vista	91911
David	Gutierrez	Los Angeles	90031-1301
Andrea & James	Gutman	Sunland	91040-1215
Mario	Guzman	San Jose	95112
Sally	Haberlin	Laguna Niguel	92677
Marc	Hachey	Concord	94518-3364
Todd	Hack	Chula Vista	91913
Ian	Haddow	San Francisco	94172-0048
Carol	Hadley	Sacramento	95978

K.	Hafer	San Clemente	92672-5285
Kim	Hagan	Castro Valley	94546-1369
Tracy	Hageman	Victorville	92393-0862
Brooke	Hagy	Santa Ana	92707-4762
Brenda	Haig	Long Beach	90803-2303
James	Haig	San Rafael	94901-3706
Merina	Halingten	Belmont	94002-1432
Holly	Hall	Temecula	92592-6484
Christopher	Hall	Glendale	91203-1020
Stacy	Hall	San Diego	92104
Sue	Hall	Castro Valley	94546
Stuart	Hall	San Francisco	94102-1228
Ellen	Hall	Pacifica	94044-3343
Eric	Hall	San Francisco	94107
Bruce	Hall	Pasadena	91101
Lyne	Hamel	Oceano	93445-8903
Jeanine	Hames	Burbank	91502-2393
Graham	Hamilton	Santa Monica	90405-1543
Pamela	Hamilton	West Sacramento	95605-3226
Frederick	Hamilton	Rancho Cucamonga	91739-1925
Robin	Hamlin	Mckinleyville	95519-9463
F	Hammer	San Francisco	94123-3118
David	Hammond	Willits	95490-8764
Luerra	Hammond	South San Francisco	94080
Pamela	Hammond	Fairfax	94930
Susan	Hampton	El Cerrito	94530-2228
Sharon	Handa	San Francisco	94131-1034
Susan	Hanger	Topanga	90290-3551
Ki	Hani	Hayward	94541-5008
Charlotte	Hanigan	Fresno	93705
Mark	Hanisee	Riverside	92506-4708
Penny	Hannon	Carpinteria	93013-2117
Kathleen	Hanold	Costa Mesa	92626-3512
Jill	Hansen	Fair Oaks	95628-5953
Karin	Hansen	Oakland	94609-1527
Jane	Harada	Berkeley	94709-1422
Suzanne	Hard	Murrieta	92563-4857
Ann	Harding	Campbell	95008
Lynne	Hargett	Lompoc	93436-6344
Jana	Harker	Arcadia	91066-0793
Rebecca	Harper	Los Angeles	90049-1220
Charesa	Harper	Glen Ellen	95442-9743
Barbara	Harper	Castroville	95012-2926
Silva	Harr	Concord	94521-2205
Gabrielle	Harradine	Malibu	90265-3051
Bryan	Harrell	San Francisco	94114-2313

Brianna	Harrington	Vallejo	94559
David	Harris	Ventura	93003
Beverly	Harris	Beverly Hills	90212-3505
Shirley	Harris	Willits	95490
Lois	Harris	Claremont	91711
John	Harris	Bay Point	94565-2944
Beverly	Harris	Red Bluff	96080-3729
Laurel	Harris	Rutherford	94573-0088
Lois	Harris	Claremont	91711-2753
Penny	Harris	Eureka	95503-3489
Ajila	Hart	San Francisco	94110-5223
Steph	Hart	Newport Beach	92663-2730
John	Harter	Marina	93933
Erfin	Hartojo	Walnut	91789-4104
Deborah	Hartsough	San Diego	92109-2204
Brit	Harvey	Berkeley	94702-2247
Claudia	Hasenhuttl	Glendale	91206-4621
David	Haskins	San Diego	92105-3676
Jerri	Hatch	Carlsbad	92011-5122
Nadine	Hatcher	Camarillo	93010-2016
James	Hatchett	Reseda	91335-1831
Susan	Hathaway	Pico Rivera	90660-2842
Samantha	Hathaway	La Verne	91750-4224
Paula	Hawkins	San Diego	92104-4308
Terry	Hawkins	San Francisco	94109
John	Hawkins	Newbury Park	91320-3561
Laura	Hawkins	Cottonwood	96022-9717
Alys	Hay	Windsor	95492-6890
Noah	Haydon	Daly City	94015
Christine	Hayes	Upland	91786-2161
Tim	Hayes	San Diego	92115-6938
Jennifer	Hayes	Modesto	95350-1716
Sara	Hayes	Long Beach	90814-7531
Louise	Hayward	Aptos	95003
Kris	Head	Garden Grove	92843-1078
Susan	Head	Sausalito	94965-1723
Kris	Head	Garden Grove	92843-1078
Christine	Headworth	Ramona	92065-3235
Kevin	Hearle	San Mateo	94402
Sarah	Hearon	Santa Barbara	93130
Elizabeth	Hecker	Yorba Linda	92833
Jennifer	Heddle	Alameda	94501
Jim	Hedgecock	Pine Grove	95665-9738
Judith	Heffron	La Verne	91750-2102
Gaille	Heidemann	Los Angeles	90024-5130
Jessica	Heiden	Eureka	95503

Todd	Heiler	Arcata	95521
Janet	Heinle	Santa Monica	90403-4066
Bridgett	Heinly	San Diego	92107-4210
Penny	Heintz	Cedar Ridge	95924-0362
Margaret	Helfrich	Capo Beach	92624
Lesle	Helgason	Pebble Beach	93953-3043
Karen	Hellwig	Los Angeles	90056-1737
Jeffrey	Hemenez	San Jose	95133-2333
Peter	Hemenway	San Francisco	94127-1723
Martin	Henderson	Goleta	93117
Ralph	Henslee	Hemet	92543-5737
Venedel	Herbito	Los Angeles	90042-3424
Diane	Herbs	Indio	92203-7408
Melvin	Herlin	Laguna Niguel	92677-5724
Birgit	Hermann	San Francisco	94117-2594
Janet	Hermer	Huntington Beach	92648-6812
Nicholas	Hermosillo	Highland	92346-1819
Thomas	Hernandez	Corona	92881
Connie	Hernandez	Santa Clara	95050-5821
Dena	Hernandez-Kosche	Glendale	91201-2585
Beth	Herndobler	Pasadena	91106-1319
Ana	Herold	Pacifica	94044-3631
Joan	Heron	Fort Bragg	95437-4204
Jo Ann	Herr	Oakland	94602-3948
Sandra	Herrera	Reedley	93654-2352
Darlene	Herrington	San Jose	95125
Susan	Herting	Oakland	94619-1525
Randall	Herz	San Jose	95117-2312
Amanda	Heske	Fullerton	92833-1262
Rilla	Heslin	La Mesa	91944-0982
Darienne	Hetherman	Altadena	91001-4726
Suzanne	Hewey	San Diego	92123-3819
Carol	Hewitt	Signal Hill	90755-3452
Joyce	Heyn	Poway	92064-4071
Lacey	Hicks	Fremont	94536-1829
Robert	Hicks	Long Beach	90803-8239
Leslie	Hicks	Los Angeles	90035-2635
Rosemary	Hieber	Mission Viejo	92692-5181
Michael	Hieda	Laguna Hills	92653-5617
Diane	Hightree	North Highlands	95660-3802
Amy	Hile	Oak Park	91377-1115
Irene	Hilgers	San Ramon	94582-5359
Eloise	Hill	Alameda	94501-3797
Daisy	Hill	Vista	92084-3513
Frank	Hill	Cathedral City	92234

Terry	Hill	San Francisco	94121-3830
Henry	Hinds	San Rafael	94903-3125
Richard	Hirai	Eureka	95501-1790
Lisa	Hirayama	Napa	94558
Monique	Hitzman	Santa Monica	90401-2023
Ah	Ho	Foster City	94404-1805
Bao	Ho	San Jose	95111
Suzanne	Hodges	Rancho Cordova	95670
Mary	Hodgson	Tracy	95377-6607
Iris	Hoevelaak	Venice	90291-2423
John	Hoffman	Whittier	90602-3102
Mary	Hoffman	Santa Barbara	93105-3277
Robert	Hoffmann	Sheep Ranch	95246-9579
Kerry	Hogan	San Mateo	94403
Marti	Hokans	Santa Ana	92703-4023
Cathy	Holden	Sacramento	95865-4733
Carla	Holguin	Los Angeles	90027-1334
Brett	Holland	Los Angeles	90026-5142
Carol	Holland	Costa Mesa	92627
Roger	Hollander	Tarzana	91356-5728
Nancy	Holleman	Santa Ana	92705
Paula	Hollie	Laguna Woods	92637-8849
Barbara	Hollis	Kentfield	94904-2546
Candace	Hollis-Franklyn	Belvedere Tiburon	94920-1325
David	Holloway	Rocklin	95765-5903
Monika	Holm	Oakland	94611-2143
Jane	Holt	Los Altos	94024-6907
Lynne	Holt	Lake Forest	92630-8039
Steve	Holzberg	Fair Oaks	95628-6506
Celeste	Hong	Los Angeles	90027-1144
Susan	Hood	Sacramento	95821-5277
Stoney	Hooker	San Diego	92121
Clare	Hooson	Belmont	94002-3511
Janet	Hoover	Garden Grove	92845-2946
Dennis and Andrea	Hopkins	Monrovia	91016-1514
Bridget	Hopkins	Pacheco	94553
Jerry	Horner	Concord	94518-2322
Carolyn	Horowitz	West Covina	91791-2100
Laura	Horton	Santa Ana	92705-8632
Eric	Horwitz	Lake Forest	92630-3523
Barbara	Hosmer	Mission Viejo	92691-5602
Michael	House	Redwood City	94061-3543
William	Houston	Scotts Valley	95066-2802
Roseanne	Hovey	San Diego	92117-2394
Erin	Howard	Oakland	94602-2221

Brandyce	Howard	Long Beach	90807-6906
John	Howard	Venice	90291
Sherrie	Howell	Pleasanton	94588-4347
Kari	Howell	Hemet	92543-8708
Brianna	Howell	El Dorado Hills	95762
Linda	Howie	Valencia	91355
Amy	Howk	Santa Cruz	95062-3357
Angela	Hoyes	Alta Loma	91737
Laurie	Hrdlicka	Big Bear City	92314
Karissa	Huang	Sunnyvale	94086-8230
R	Huber	Oceanside	92054-6022
Lorie	Huckaba	Roseville	95678-5987
Molly	Huddleston	Santa Rosa	95402-1119
Janis	Hug	Santa Rosa	95405-7805
Vicki	Hughes	Huntington Beach	92648-2861
Kathryn	Hughes	Riverside	92505
Sukey	Hughes	Santa Ynez	93460
Rich	Hughes	San Francisco	94112-2036
Maria	Hughes	Pasadena	91104-4008
Maggie	Hughes	Berkeley	94704-2247
Renee	Hular	Belmont	94002-1928
Joy	Humeny	San Leandro	94579
Saroyan	Humphrey	San Francisco	94117-2617
Paul	Hunrichs	Santee	92071-2206
Linda and Milton	Hunt	Pasadena	91104
Keith	Hunter	Carlsbad	92008-1049
Adrian	Hurley	Encino	91316-4332
Gillian	Hurley	Encino	91316-4332
Bradley	Husted	Vacaville	95687-4722
Melissa	Hutchinson	Pacific Grove	93950
Leslie	Hutchinson	Cottonwood	96022-8598
Graciela	Huth	Los Angeles	90045-3707
Frank	Huttinger	Pasadena	91105
Colin	Hyatt	Santa Barbara	93109
Jinx	Hydeman	Trabuco Canyon	92679-1108
Kathleen	Hynes	San Francisco	94109-2827
Vonnie	Iams	Poway	92064-2040
Deborah	Iannizzotto	Escondido	92027-3976
Hanna	Ibrahim	Long Beach	90815
Neil	Illiano	Sausalito	94965-1315
Kim	Ina	Daly City	94014-1992
Maryan	Infield	Los Angeles	90068-1410
Kajsa	Ingelsson	West Hollywood	90046-4553
Evan	Ingle	San Diego	92111-7006
Sally	Ingram	Occidental	95465-0698

Lynn	Ireland	Larkspur	94977-1175
Martin	Iseri	Fair Oaks	95628-6916
Tasha	Isolani	Berkeley	94708-1226
Sheryl	Iversen	Murrieta	92563
Dehra	Iverson	Costa Mesa	92627-2908
Cathy	Ives	San Diego	92109
Gregory A	Jackson	Los Angeles	90046-4223
Kathleen	Jackson	Gilroy	95021-1587
Madison	Jackson	Millbrae	94030-2559
Stephen	Jacobs	Los Angeles	90028-7808
Trudy	Jacobs	Sacramento,	95835
Laura	Jacobson	Walnut Creek	94595
Karen	Jacques	Sacramento	95811-7105
Lisa	Jaime	Los Angeles	90019-3158
Paula	Jain	Nevada City	95959
Christine	James	Palo Alto	94306-3114
Arlene	James	Daly City	94015-3066
Anthony	Jammal	Roseville	95661-5968
Hoku	Janbazian	Monrovia	91016-3769
Hillie	Janssen	Rancho Mission Viejo	92694-1810
Stormy	Jech	Santa Cruz	95065-1219
Joyce	Jeckell	Sunnyvale	94087-5203
Helen	Jeffers	North Hollywood	91601
Brian	Jeffery	Temecula	92592-9602
Julien	Jegou	Irvine	92618-3417
Jemma	Jemma	Citrus Hts	95610
Jeffrey	Jenkins	Diamond Bar	91765-1256
Christopher	Jennings	Banning	92220-4726
Lisa	Jensen	Santa Cruz	95062-2916
Laurie	Jensen	Campo	91906
Renee	Jeska	Seal Beach	90740-2958
Lawrence	Jimenez	Los Angeles	90068-2234
Cyndee	Jimenez	Rancho Cucamonga	91730-6312
Martha	Jimenez	Alameda	94501-5648
Fernando	Jimenez	Compton	90221
Claire	Joaquin	Pollock Pines	95726-9013
Heather	John	Inglewood	90302-1309
Andrew	Johns	El Sobrante	94803-1736
Sage	Johnson	San Francisco	94133-2468
Chad	Johnson	Sylmar	91342-5162
Robert	Johnson	El Segundo	90245-3259
Shawn	Johnson	Encinitas	92024-4552
Gregg	Johnson	San Jose	95126-5006
Mara	Johnson	Santa Clarita	91390
Matthew	Johnson	Anaheim	92801-1327
Alice	Johnson	Sacramento	95841-4713

Tyler	Johnson	Orange	92865
Elizabeth	Johnson	Albany	94706
Jennifer	Johnson	Oxnard	93035-2961
Kyle	Johnson	Auburn	95603-3911
Karen	Johnson	Laguna Hills	92653-4332
Michael A.	Johnston	San Diego	92176
Paul	Jokelson	Oakland	94606-1257
Mike	Jones	West Hills	91307
Rev. Allan B.	Jones	Santa Rosa	95404
Chris	Jones	Alameda	94501-2555
Sam	Jones	San Jose	95123-5315
S	Jones	Costa Mesa	92627-0227
Jan	Jones	El Cerrito	94530-1437
Ronald	Jones	San Diego	92107-3712
Bonnie	Jones	Albany	94706-1641
Kathy	Jones	La Quinta	92253
Charles	Jones	Santa Rosa	95409-3207
Shelya	Jones	Altadena	91001
Kelly	Jones	Truckee	96161
Shawn	Jones-Bunn	Avila Beach	93424-2283
Alena	Jorgensen	Temple City	91780-1651
Molly	Joseph	Glendale	91207-1447
Walter	Juchert	Santa Rosa	95409-6218
Paul	Judy	Studio City	91602-2147
Scott	Jung	South Pasadena	91030-3588
Judith	Justin	Fallbrook	92028-9373
S	Kaehn	Oakland	94601-4354
Sandra	Kagan	Valley Village	91607-3402
Pauline	Kahney	San Francisco	94102-4122
Marianne	Kai	Sherman Oaks	91403-5041
Dr. Linda	Kakish	Redondo Beach	90277
Stefanie	Kaku	Carmel	93922-0554
Carissa	Kalogiannis	Aliso Viejo	92656-4202
N	Kaluza	El Sobrante	94803-3857
Tara	Kamath	Santa Monica	90404-4931
Cindy	Kamler	Bishop	93514-7205
Margaret	Kane	Walnut Creek	94596-4940
Sakurako	Kanemitsu	Sacramento	95825
Eileen	Kaniefski	Yucca Valley	92284-5106
Constance	Kao	San Francisco	94110-6104
Eliot	Kaplan	Woodland Hills	91364
Adam	Kaplan	Laguna Beach	92651-1845
Adele	Kapp	La Jolla	92037-4223
Chuck	Karp	Palm Desert	92261
Sally	Karste	San Anselmo	94960-2845
Michael	Kast	Panorama City	91402

Lise	Kastigar	Laguna Niguel	92677-2720
Vicki & Rod	Kastlie	San Diego	92107-2310
Paul	Katz	Aromas	95004-9710
Samantha	Katz	Palmdale	93550-5065
Joanne	Katzen	Aptos	95003-4023
Sue	Kauffman	Laguna Niguel	92677-7039
Andrea	Kaufman	Guerneville	95446
Rick	Kawakami	Bellflower	90706-5215
Robert	Keats	Santa Barbara	93101-3071
Wesley	Keebler	Sherman Oaks	91403-1043
Lori	Kegler	San Pedro	90731-6213
Edward	Kehler	San Francisco	94122-2145
Shannon	Keifner	Chatsworth	91311-4745
Sheila	Keith	Carmel	93923-9204
Kathleen	Kelehan	Los Angeles	90041-3434
Nancy	Keleher	Ferndale	95536-1327
Lisa	Kellman	San Francisco	94131-2229
Keith	Kellogg	Santa Cruz	95060
Mike	Kelly	San Diego	9211-7589
Joanna	Kelly	Studio City	91604-4505
Katrina	Kemnitzer	San Juan Capistrano	92675-6319
Jane	Kemp	Fallbrook	92028-8517
Michael	Kenney	El Cerrito	94530-1610
Ian	Kent	Kirkwood	95646
Schuyler	Kent	Los Angeles	90020-4731
Nancy	Kenyon	Irvine	92612-2230
John	Kerby	Fontana	92336-1085
James	Kerr	Redwood Valley	95470-0679
Evangeline	Kidd	San Diego	92107-2819
Charles	Kieser	San Francisco	94117
Vanessa	Killingsworth	San Diego	92102-2213
Audrey	Kim	Pasadena	91106-2140
Elli	Kimbauer	Crescent City	95531-2152
Sandy	Kimble	Oceanside	92058
Marcia	Kimmell	Berkeley	94705-1363
Lauren	Kimple	San Francisco	94130-1042
Jeanette	King	Livermore	94550
Travis	King	North Hollywood	91601-4519
Barbara	King	Los Angeles	90029-0448
Daly	King	Los Altos	94022-3481
Stephen	King	San Francisco	94110-2922
David	Kinkaid	San Diego	92110-2304
Laurie	Kinnings	Garden Grove	92841-4918
Alana	Kirby	Alameda	94501-1456
Gale	Kirk	Newport Beach	92660-0708
Peggie	Kirkpatrick	Yorba Linda	92886-4529

Karen	Kirschling	San Francisco	94117
Patrick	Kissel	San Marcos	92078-1047
Betty	Kissilove	San Francisco	94122-3636
Elmone	Kissling	Eureka	95503
Marc	Kitaen	El Cajon	92021-2441
Koko	Kittell	Newark	94560-2616
Kathleen	Klauer	Santa Rosa	95407-5022
Dina	Klayman	Calabasas	91302-1366
Suzanne	Klehr	Vallejo	94590
Leslie	Klein	Los Angeles	90027-3480
Renee	Klein	Marina Del Rey	90292-7086
Linda	Klein	El Segundo	90245-3259
Shirley	Klein	San Diego	92122-1130
Priscilla	Klemic	Sherman Oaks	91401
Diana	Kliche	Long Beach	90804-1201
Martina	Klingenfuss	Belmont	94002-4101
George F.	Klipfel II, CLS	Cathedral City	92234
Megan	Klopp	Danville	94526-3928
Thomas	Knecht, MD, PhD	Avila Beach	93424-0742
Deanna	Knickerbocker	Santa Clara	95050
Kendra	Knight	Millbrae	94030-2333
Patricia	Knight	San Diego	92111-4616
Nancy	Knipe	Studio City	91604-1611
Kristeene	Knopp	Emeryville	94608-2814
Elena	Knox	Volcano	95689
Skaie	Knox	Manhattan Beach	90266-3431
Mason	Kocel	Oceanside	92057
Cindy	Koch	Long Beach	90807-3020
Sharon	Kocher	Sebastopol	95472-6411
Diana	Koeck	Costa Mesa	92627
Beth	Koenigsberg	Los Angeles	90068
Karl	Koessel	Mckinleyville	95519-8168
Laura	Kohn	Hillsborough	94010-6208
Joyce	Kolasa	Springville	93265
Patricia	Kolchins	Calabasas	91302-3167
Marilyn	Konish-Dunn	Woodland	95695-3940
Lori	Koon	San Francisco	94110
Jennifer	Kopczynski	Thousand Oaks	91360-2001
Maria	Korcsmaros	Corona	92882
Michelle	Kosinski	Goleta	93117-1500
Kathy	Kosinski	Goleta	93117
Terry	Kourda	Chula Vista	91913
Rick	Koury	Los Gatos	95032-1136
Aylene	Kovary	Sherman Oaks	91423-1902
Leslie	Kowalczyk	Sonora	95370-8618
Cheryl	Kozanitas	San Mateo	94403-1240

Lauren-Michelle	Kraft	Mission Viejo	92692-1189
Janie	Krag	Los Gatos	95032
Julie	Kramer	San Francisco	94114-3918
Carole	Kramer	Sonoma	95476-3903
Cathy	Kraus	North Hollywood	91606-4210
Doug	Krause	San Diego	92101-1233
Sue	Kremer	Solana Beach	92075-0285
Michael	Kreutzburg	Rancho Cordova	95670-2850
Lorna	Kriss	Sausalito	94965
Catherine	Krueger	El Cerrito	94530-3746
Henry	Kruger	Eureka	95501-0318
K	Krupinski	Los Angeles	90042-1348
Jon	Krupp	Pacifica	94044
Alfredo	Kuba	Mountain View	94043-3438
Francine	Kubrin	Los Angeles	90049
Allard	Kuijken	Long Beach	90803-1537
Mark	Kupke	Santa Rosa	95401
Nancy	Kurtz	San Francisco	94116-2620
Sabine	Kurz-Sherman	San Marcos	92078
Carol	Kuzdenyi	Pacific Grove	93950-2551
Rochelle	La Frinere	San Diego	92114-6723
Joseph	La Marche	Ontario	91764
Laakea	Laano	Oakland	94611-4862
Jason	Laberge	Malibu	90265
Georgia	Labey	Lakeside	92040-3838
Sally	Lacy	Laguna Woods	92637-8511
Elizabeth	Ladiana	Ventura	93003-0626
L.	Laffitte	Pismo Beach	93448
Molly	Lafley-Evans	Huntington Beach	92646
Anne	Lakota	Novato	94949-6719
Frances	Lam	Irvine	92604-3070
Francisco	Lamarque	Highland	92346
Janet	Lambert	Sonoma	95476
David	Lamiquiz	Mountain View	94043-2964
Jim	Lamport	Garberville	95542
Deborah	Lancman	La Mesa	91941-6923
Joyce	Landau	Woodland Hills	91364
Dennis	Landi	Los Angeles	90003-2821
Dana	Landis	San Francisco	94131
Stefanie	Landman	Fremont	94539-5217
John	Landmann	San Diego	92101-6730
Marisa	Landsberg	Manhattan Beach	90266-6605
Ron	Landskroner	Oakland	94611
Lama	Lane	Santa Ana	92704-6205
Susan	Lane	Vallejo	94591-4044
Ann	Laner Kaplan	Mill Valley	94941-4050

Pat	Lang	Los Altos Hills	94022-4531
Jeri	Langham	Sacramento	95827
Cheri	Langlois	Mendocino	95460-1286
Erica	Lann-Clark	Soquel	95073
Kathryn	Lanning	Visalia	93277
Paul	Lapidus	Aromas	95004-9712
Joann	Lapolla	San Diego	92122-3826
Roshanee	Lappe	San Pedro	90732-6090
Herlinda	Lara	National City	91950-4424
Venetia	Large	Altadena	91003
Hooman	Larimi	Concord	94518-2341
Lucy	Larom	San Diego	92102
Nadine	Larsen	Dana Point	92629
Linda	Larsen	Redondo Beach	90277-2870
Eugenia	Larson	San Ramon	94582-4614
Wendy	Larson	Turlock	95380-4933
Pamela	Larue	Long Beach	90808-2417
Natacha	Lascano	Rocklin	95765-5480
Liana	Laskin	Sunnyvale	94087-5476
Patty	Lasko	Diamond Bar	91765-4475
Sharon	Lasman	North Hills	91343-2901
Susan	Laube	Aguanga	92536
Patricia	Lauer	Signal Hill	90755-6013
Gail	Lauinger	Mendocino	95460-9704
Janet	Laur	Chatsworth	91311
Julie	Lavell	Los Osos	934021
Chrysanthi	Lawrence	Richmond	94805-2013
Carol	Lawrence	Mckinleyville	95519-3448
Diana	Lawton	Berkeley	94709-1443
Dorri	Lawyer	Murrieta	92562-5222
Scott	Laxier	Del Rey Oaks	93940-5727
Misti	Layne	San Francisco	94118
Jamie	Le	Alameda	94501-2341
Susan	Lea	Studio City	91604-3709
Jan	Leath	Glendale	91205-3629
Candy	Leblanc	Placerville	95667
Harlan	Lebo	La Mirada	90637-0614
Karyn	Lebrun	Escondido	92027-4246
Karen	Lebrun	Alhambra	91803-3651
Javier	Ledesma	Fontana	92337
Andrew	Lee	South San Francisco	94080-5516
Ruby	Lee	Richmond	94801-3123
Peter	Lee	Pomona	91766-4200
Elsa	Lee	Cerritos	90703-8517
Susie	Lee	La Habra	90631-7018
Jean	Lee	San Francisco	94122-2506

Vicki	Leeds	Point Reyes Station	94956-0398
Jason	Leffingwell	Walnut Creek	94596-5305
Tanirose	Legaspi	San Diego	92139-3623
Stephen	Leighton	Los Angeles	90035-2580
Roger	Lema	Hayward	94541
Denise	Lenardson	Sunland	91040-1916
Nicholas	Lenchner	Santa Rosa	95403
C	Leonard	San Bernardino	92404-2919
Lauren	Leonarduzzi	Gilroy	95020-3018
Lynne	Lerner	Van Nuys	91406-5226
Amy	Leroy	Santa Rosa	95403-2913
Linda	Leruth	Encinitas	92024-2641
Jim	Leske	North Hills	91343-1407
M. Virginia	Leslie	Milpitas	95035-3532
Leslie	Leslie	Mill Valley	94941-3448
Tamara	Lesser	Agoura Hills	91301-3358
Harriet	Levenson	Tarzana	91356-1706
Paul	Levesque	San Diego	92163-1291
Jeff	Levicke	Valley Village	91607
Marilyn	Levine	Mountain View	94041-1640
Katie	Levine	Los Angeles	90042-3220
Lacey	Levitt	San Diego	92120-2717
Jason	Levitt	Los Angeles	90013-1679
David	Levy	San Francisco	94133-2660
Claire	Levy	San Francisco	94102-5209
O	Lewis	Los Angeles	90009-7075
Donna	Lewis	Van Nuys	91401-4106
Linda	Lewis	Del Mar	92014-3838
Ashley	Lewis	San Anselmo	94960-2260
Lisa	Lewis	Santa Cruz	95062-3326
Nora	Lewis	Nipomo	93444-9736
Patrick	Lewis	San Rafael	94901-4462
Sherman	Lewis	Hayward	94542-1616
Li	Li	San Bruno	94066-3618
Naomi	Lidicker	Kensington	94707-1235
Sharon	Lieberman	Annapolis	95412
Nancy	Lieblich	Berkeley	94709-1204
Amy	Liebman	Burlingame	94010-2626
Paul	Lifton	Richmond	94805-1150
Diana	Light	Irvine	92612-1712
Linda	Lightfoot	Burbank	91506
David	Lin	San Francisco	94124-2769
Ching-Yi	Lin	Vista	92081-4554
Emily	Lin	San Diego	92123-6428
Stephanie	Linam	Benicia	94510
Kayahna	Lincoln	Santa Rosa	95409

Michelle	Lind	Hawthorne	90250-6455
Vince	Lindain	Fremont	94555-3236
Connie	Lindgren	Arcata	95521-8236
Bill	Lindner	San Rafael	94903-1436
Bev	Lips	San Francisco	94104-4905
Patricia	Little	Camarillo	93010
Robyn	Little	Napa	92277
James	Littlefield	Aptos	95003
Florence	Litton	Valley Center	92082-7331
David	Liu	Mountain View	94041
Elaine	Livesey-Fassel	Los Angeles	90064
Linda	Livingston	Ojai	93023-3826
John	Livingston	Redding	96001
Marilyn	Livote	Buena Park	90621
Lynne	Llerena	San Jose	95129-3224
Gilly	Lloyd	San Rafael	94903-3773
George	Lloyd	Placerville	95667-8439
Dana	Loats	Los Angeles	90065-2503
Pat	Locks	Sonoma	95476
Marilyn	Logan	Valencia	91355-3062
Wendy	Lohman	Los Angeles	90024-4849
A. Somerset	Lokken	San Francisco	94115
Steve	Lombard	Encino	91316-1414
Lorraine	Lombardo	San Diego	92128-7203
Joan	Loney	Los Altos	94024-6204
Amy	Longanecker	San Diego	92111-7226
Jon	Longsworth	Aptos	95001
Debbie	Longwith	Tujunga	91042
Marco	Loo	Escondido	92029-3051
Chris	Loo	Morgan Hill	95037-3864
Ralph	Lopez	Los Angeles	90012-5017
Jennifer	Lopez	Whittier	90604-3558
Iliana	Lopez	Palmdale	93591-3240
Rosa	Lopez	Panorama City	91402-3806
Margaret	Lopez	Long Beach	90803
Erik	Lorton	San Diego	92104
Catherine	Loudis	San Anselmo	94960-1242
Rachel	Loui	Mountain View	94040-1278
Suzanne	Louie	San Francisco	94127-2327
Dennis	Love	Pinon Hills	92372-0102
Darlene	Lovell	Bakersfield	93301
Lynn	Lovingood	Corona	92880-5404
Carol	Lowe	Redding	96001
Cara	Lowe	Kentfield	94904-2610
Melina	Lowe	Westminster	92683-7631
William	Lowe	Westminster	92683-7631

Shannon	Lowe	Westminster	92683-7631
Jill	Lowell	Benicia	94510-2663
Marsha	Lowry	El Sobrante	94803
Diana	Lubin	La Mesa	91941-7121
Thalia	Lubin	Woodside	94062-4166
Janie	Lucas	San Francisco	94110-3224
Rosa	Lucas	Palm Desert	92260-2665
Penny	Luce	Santa Barbara	93111-1830
Monica	Lucero	Martinez	94553-6623
Minerva	Lucero	Los Angeles	90066
George	Ludwig	Vista	92084-4208
Inez	Lujan	Baldwin Park	91706
Natalie	Lum	Tracy	95377
Andrea	Luna	Fallbrook	92028-4518
Jennifer	Luna-Repose	Lafayette	94549-2242
Cindi	Lund	Danville	94526-3909
Susan	Lund	Carlsbad	92010
Andy	Lupenko	Lemon Grove	91945-2615
Alicia	Lutsuk	Sacramento	95842
Linda	Lyke	Los Angeles	90065
W	Lynch	Los Angeles	90049-1022
Michal	Lynch	Santa Barbara	93111-1305
Rosann	Lynch	Monterey	93940-1133
Susan	Lynch	Pacific Palisades	90272-3909
Marsha	Lyon	San Diego	92116-7600
Angela Treat	Lyon	Chico	95926-3487
Jeremy	Lyons	West Hollywood	90046-5934
Gail	Lytle	Turlock	95382-2849
Edward	Macan	Eureka	95501
Catherine	Macan	Eureka	95501-2564
Scott	Macdougall	Berkeley	94709-1519
Sherry	Macias	Sacramento	95825-6610
Michael	Maclafferty	Oakland	94612-3928
Lawrie	Macmillan	Modesto	95355-7821
Tawny	Macmillan	Elk	95432-0123
Bonnie	Macraith	Arcata	95521-5119
Chris	Macy	Paso Robles	93446-2258
Bryan	Maddan	Palm Desert	92211-2795
Susanne	Madden	Playa Del Rey	90293-8068
Scott	Madia	Santa Rosa	95407-7884
Sally	Madigan	Meadow Vista	95722-9575
Andrea	Madrigal	Santa Ana	92707
Brendan	Maghran	Encino	91316-2145
Pat	Magrath	Pomona	91767-3566
Laurie	Maguire	Sebastopol	95472-4442
Richard	Magwood	Panorama City	91402-6523

Mary	Maher	Milpitas	95035-4332
Alison	Mahin	Carmichael	95608-4442
Jack	Mahrt	Morro Bay	93442-2944
Cecilia	Maida	Shingle Springs	95682-7219
Eugene	Majerowicz	View Park	90008-4821
Glenn	Majeski	South San Francisco	94080-5903
Janet	Maker	Los Angeles	90024-3113
Lisa	Maker	Concord	94520-3766
Serena	Makofsky	Santa Rosa	95404-5698
Susan	Maletsky	Sonora	95370-8435
Madeline	Malin Price	Los Angeles	90024-5164
Sheila	Malone	Yucaipa	92399-3410
Marc	Maloney	Sacramento	95841
Ilene	Malt	San Anselmo	94960-1327
Marian	Mankos	Palo Alto	94301-4140
Jacquelyne	Mann	Bakersfield	93304
Patricia	Mann	Indio	92201-9514
Audrey	Mannolini	Huntington Beach	92646-2612
Jonathan	Mansell	Westminster	92683-2647
Michael	Marcella	Grass Valley	95949-7630
Steve	Mark	Rossmoor	90720-3022
Stephen	Markel	Los Angeles	90066-5416
Kevin	Markoe	Watsonville	95076-2223
Melissa	Marquez	Placerville	95667
Madeline	Marrow	Richmond	94801-3433
Joe	Marsala	Fairfield	94534-8603
Debbie	Marsh	Poway	92064-4745
Dorrine	Marshall	Irvine	92620-2024
Raymond	Marshall	Foresthill	95631-9201
Val & Kirk	Marshall	Fort Bragg	95437
Jaime	Marshall	Santa Monica	90404-1427
Nancy	Martin	Palo Alto	94303-4858
Chase	Martin	Alameda	94501-2834
Ben	Martin	Mountain View	94040-1483
Joanna	Martin	Mission Viejo	92691-3721
C.	Martin	San Francisco	94108
Tyson	Martin	Burbank	91505-3742
Jeffrey	Martin	Fremont	94538-3957
Dayna	Martinez	La Mesa	91941
Birgitta	Martinez	Los Angeles	90041-3144
Melissa	Martinez	Los Angeles	90066
Linda	Martinez	Los Angeles	90032-2625
Elissa	Martinez	Huntington Beach	92648-6423
Daniela	Martinez	Pinon Hills	92372-9340
Adriana	Martinez	Los Angeles	90018-2434

Ana-Paula	Martins-Fernandes	Redwood City	94065-1796
M	Masek	Danville	94526-3739
James	Masi	San Francisco	94158-1663
Richie	Masino	Del Mar	92014-2637
Grace	Mason	San Jacinto	92583-6562
Christina	Mason	Foster City	94404
Joy	Massa	Sausalito	94965-1159
Becky	Mastoras	Dublin	94568-1512
Helen	Matosich	San Francisco	94118-4340
Mayumi	Matson	Piedmont	94611-4357
Mari	Matsumoto	Alameda	94501-1509
Rhonda	Matthews	Irvine	92604-3326
Michele	Mattingly	El Cajon	92021
Vicki	Maturo	Santa Monica	90404
Amanda	Mauceri	View Park	90043
Tim	Maurer	Anaheim	92808-1619
Casee	Maxfield	Los Angeles	90028-8674
Geraldine	May	Creston	93432-9773
Julie	May	Los Angeles	90034-1119
Joe	May	El Cajon	92019-3770
Tabitha	Maya	Bakersfield	93309-1331
Cynthia	Mayes	Pollock Pines	95726-9017
Katherine	Maynard	Pacific Palisades	90272-4241
Denise	Mayosky	Milpitas	95035-5708
David	Mazariegos	Folsom	95630-2675
John	Mc Comas	El Cerrito	94530
Nico	McAfee	Belvedere Tiburon	94920-2048
Mary	McAuliffe	Los Angeles	90028-6414
Diana	McBride	San Rafael	94901
Janelle	McCarthy	Newark	94560-2668
Cynthia	McCarthy	Rancho Mission Viejo	92694
C	Mccarty	Encinitas	92024
Karen	McCaw	View Park	90043-2012
Katrina	McClary	Murrieta	92563
Heather	Mcclintock	Glendale	91207
Kalyn	McCloud	Port Hueneme	93044-2244
Sudi	McCollum	Glendale	91206-1419
Barney	McComas	San Diego	92103-7600
Douglas	McCormick	Trabuco Canyon	92679-4123
Mary Ann	McCoy	Torrance	90505-2716
Jeannine	McCullagh	San Diego	92127
Christina	McCulley	Princeton	95970-9511
Kimberly	McCullough	San Jose	95112-2715
Kimberly	McCullough	San Jose	95122
Shereen	McDade	Los Angeles	90018-4314

Evan	McDermit	Fullerton	92832-1110
Stacey	McDonald	Thousand Oaks	91361-5004
Pamela	McDonald	Riverside	92505-2221
Maureen	McDonald	Los Angeles	90068-2334
Tom	McDonald	Los Angeles	90027-2207
Joseph	McDonough	Hemet	92544-6723
Carole	McElwee	Irvine	92603-0121
Modell	McEntire	San Bernardino	92405
Modell	McEntire	San Bernardino	92405-3136
Patty	McFerrin	Sonoma	95476-5941
Kerri	McGoldrick	Castro Valley	94546-6350
Jane	McGraw	San Bernardino	92404-1761
Stepheny	McGraw	Palo Alto	94303-4221
Fionnuala	McGregor	Cathedral City	92234
Heather	McHugh	Oakland	94611-2534
Daniel	McKeighen	Rocklin	95765-6253
Kevin	McKelvie	Palm Springs	92264-9385
Jeannie	Mckenzie	Oakland	94611-1244
Monica	McKeown-Gallicho	Concord	94521-3973
Suzanne	McKinnon	Rancho Cucamonga	91739-8624
Rita	McKissick	San Jose	95132
Linda	McLain	Lancaster	93535
Susan	McLaughlin	Foothill Ranch	92610-2429
Laurie	McLaughlin	San Diego	92116-2015
Alan	McLearn-Montz	Bakersfield	93306-2666
Michael	McMahan	Huntington Beach	92649-2363
Alexa	McMahan	Huntington Beach	92649-2363
Carol	McMahon	Placerville	95667-8153
Gail	McMullen	Los Angeles	90027
Anita	McMurtrey	Exeter	93221
Terence	McNamee	San Francisco	94115-3888
Nina	McNitzky	Redwood City	94065-1326
Jim and Leslee	McPherson	San Mateo	94403-3827
Sandra	McPherson	Davis	95616-5938
Stacey	McRae	Winchester	92596-9476
Carol	McRae	Fairfax	94930-1315
William	McRae	San Diego	92109
Jacqueline	McVicar	San Diego	92115
Pattie	Meade	San Clemente	92672-3628
Deborah	Meckler	South San Francisco	94080
Mark	Medina	Rancho Cucamonga	91737-3843
Daniel	Medrano	Wilmington	90744-1902
Juliocesar	Medrano	South Gate	90280
Mary	Meehan	Los Angeles	90035-1066
Don	Meehan	San Jose	95124-5939

Halley	Meiron	Glendale	91204
Lily	Mejia	Hemet	92543-8820
Gardenee	Mejia	Arcadia	91007
Desteny	Mejia	Arcadia	91007
Linda	Mellen	Newport Beach	92661-1434
Katherine	Mellis	Los Altos	94024
Mariana	Mellor	Thousand Oaks	91360-4250
Mika	Menasco	San Diego	92114-2810
Scott	Mendelsohn	Novato	94947-2109
Salvador	Mendoza	Gustine	95322
Miranda	Mendoza	Santa Rosa	95401-6124
Christopher	Mendoza	San Diego	92102-3676
Sandra	Menjivar	Pomona	91768-2415
Michael	Merlesena	San Diego	92109-5423
Diane	Merrick	Vallejo	94590-6429
Beth	Merrill	Newbury Park	91320
Joan	Merrill	Pleasant Hill	94523-3643
William	Mertely	Fremont	94538-6325
Barbara	Mesney	Los Angeles	90066-3018
Kim	Messmer	Santa Clara	95051-1154
Twyla	Meyer	Pomona	91767-1830
Tanya	Meyer	Woodland	95695
Greta	Meyerhof	San Clemente	92672-3419
Cindy	Meyers	La Selva Beach	95076-1609
Donna	Meyers	Lancaster	93534
August	Michaelle	San Diego	92109
Yolande	Michaels	Topanga	90290-4246
Joanne	Michalik	San Diego	92128-1546
Patti	Mickelsen	Laguna Beach	92651-1918
Allison	Mielniczuk	Petaluma	94952-9607
Shira	Miess	Oakland	94602-3533
Jan	Mignaud	El Sobrante	94803-1634
Nicole	Mikals	Newbury Park	91320-3235
Barbara	Mikulic	San Mateo	94402-3601
Kathleen	Mikulin	Fair Oaks	95628-5850
Janet	Miller	Sherman Oaks	91423-3948
Corinne	Miller	El Cajon	92020-7818
Scott	Miller	Oakland	94608-2810
Kellie	Miller	Santa Ana	92704-6531
Lynne	Miller	Malibu	90265
John	Miller	Costa Mesa	92626
Pam	Miller	Manteca	95337-6524
Scott	Miller	Hidden Valley Lake	95467-8556
Robert	Miller	Imperial Beach	91932
Victoria	Miller	Encino	91436-1541
Toni	Miller	San Carlos	94070-3714

Heidi	Miller	North Hills	91343
Korie	Miller	Oakhurst	93644-9304
Erin	Millikin	San Diego	92154-4858
Teresa	Mills	Escondido	92029-2125
Jack	Milton	Davis	95616
Naomi	Mindelzun	Palo Alto	94303-3438
Paula	Minicucci	Alamo	94507-1748
Doug	Minkler	Berkeley	94703-2105
Rocio	Miranda	Oakland	94619-1833
Melissa	Miranda	Laguna Niguel	92677-4583
Jill	Mistretta	Kentfield	94904-1501
Ruby	Mitchell	Cupertino	95014-4407
Jessica	Mitchell-Shihabi	Antelope	95843-5935
Carol	Mock	Fremont	94536
Deimile	Mockus	Los Angeles	90004-3837
Allison	Moffett	Pasadena	91105-1404
Bianca	Molgora	San Francisco	94110-6138
Arthur	Molho	Placerville	95667-3317
Nelson	Molina	Buena Park	90620-2148
Isabel	Molloy	San Francisco	94121-3427
Lucy	Mon	Citrus Heights	95621-0137
Andrea	Monaghan	Cazadero	95421-9666
Carol	Mone	Trinidad	95570-0223
Bruce	Monfross	Fair Oaks	95628-6542
Melody	Monk	Tahoe City	96145
Myrian	Monnet	Pasadena	91101-3289
James R	Monroe	Concord	94521
Michael	Monson	El Cerrito	94530-2903
Carla	Montagno	Coarsegold	93614-9635
Laura	Montaney	San Diego	92108
Dawn	Monteith	El Sobrante	94803-2421
Jean	Mont-Eton	San Francisco	94116-2068
Todd	Montgomery	Malibu	90265-3903
Brian	Montgomery	Manhattan Beach	90266
Ian and Janeane	Moody	San Rafael	94901-8308
JJ	Moon	San Francisco	94115-2286
F	Mooney	North Hollywood	91606-4802
Kia	Moore	Piedmont	94611-3413
Edith	Moore	Palo Alto	94306-2950
Malcolm	Moore	Portola	96122-8210
Mario	Mora	Sanger	93657-2915
Stephanie	Morales	Tracy	95376-8759
Emily	Morales	Moreno Valley	92557
Emily	Moran	Merced	95340
Amy	Moreno	Porterville	93257
Lorilie	Morey	Santa Rosa	95401-4780

Joshua	Morfin	West Hollywood	90069-3814
Dan	Morgan	Rosamond	93560-6804
Tyler	Morgan	Oakland	94608
Henry	Morgen	Los Angeles	90019-2550
Karen	Morizi	San Diego	92104-5355
Deborah	Morrell	Buena Park	90620-4250
Melvis	Morris	San Marcos	92078-3950
Deborah	Morris	Danville	94526-3231
Maryjo	Morris	Redlands	92374-1619
Paige	Morris	Stockton	95209
Colleen	Morris	Santa Rosa	95409
Kimberly	Morse	Poway	92064-6432
Rich	Moser	Santa Barbara	93111-2718
Marcina	Motter	Encinitas	92024-1305
Eden	Motzkin	Los Angeles	90024
Deanna	Mousaw	Walnut Creek	94597-7917
Karsten	Mueller	Santa Cruz	95060-1766
Lindsay	Mugglestone	Berkeley	94705-1948
Sharon	Mulkey	Oceano	93445-8964
Sharon	Mullane	Los Angeles	90066-5142
Carl	Muller	Huntington Beach	92649-2114
Glenn	Mullins	Buena Park	90620-1269
Kelly	Muma	Santa Rosa	95409
Ken	Mundy	Los Angeles	90068-1262
Amy	Munnelly	Irvine	92604-4675
Julian	Munoz	San Francisco	94110-5609
Connie	Munoz	Phelan	92371-9503
Becky	Muradian	San Rafael	94901-5114
G	Muramoto	Torrance	90503-8575
Beverly	Murata	Alhambra	91801
Annette	Murch	San Diego	92103-4226
Lauren	Murdock	Santa Barbara	93110-1669
Kathleen M	Murphy	La Jolla	92037-1612
Raquel	Mustaca	Modesto	95350-4856
Tami	Myers	Sacramento	95820-3321
Mecky	Myers	Redondo Beach	90277
Donna	Myers	Citrus Heights	95621-8309
John	Nadolski	Antelope	95843-5878
Kenneth	Nahigian	Sacramento	95827
Jaime	Nahman	Topanga	90290
Janice	Nakamura	Sacramento	95816-7233
John	Nance	Palm Springs	92262
Jerry	Napombhejara	Irvine	92614-5343
Suzanne	Narducy	San Clemente	92673-3101
Tem	Narvios	San Francisco	94134
Gida	Naser	Vacaville	95687-5704

Janet	Naugle	Fresno	93725-1219
Tom	Neal	Cupertino	95014-4639
Dianne	Neal	Cupertino	95014-4639
TJ	Near	San Bernardino	92404-1256
Asheley	Needleman	Huntington Beach	92649
Miriam	Neff	Dana Point	92629-3466
Jordan	Neiman	Los Angeles	90068-2415
Brad	Nelson	Oxnard	93035-4479
Lisa	Nelson	Benicia	94510-2227
L	Nelson	Morgan Hill	95038-1954
Deborah	Nelson	Simi Valley	93065-4217
Paul	Nelson	Camarillo	93010-1027
Joelle	Nelson-Achirica	Gilroy	95020
Victor	Nepomnyaschy	North Hills	91343
Gina	Ness	Santa Rosa	95409-6326
Melody	Neuenburg	Chico	95973-0693
Alice	Neuhauser	Manhattan Beach	90266-6108
Julie	Neushul	Carlsbad	92008-3662
Cyndee	Newick	Campbell	95008-3739
Roberta E.	Newman	Mill Valley	94941
Evelyn	Newman	San Mateo	94401-3864
Guy	Nguyen	Costa Mesa	92627-4625
Kelli	Nguyen	Lemon Grove	91945-2159
Eric	Nichandros	Castro Valley	94552
Linda	Nicholes	Huntington Beach	92649
Debra	Nichols	Palmdale	93551-3941
Debra	Nichols	La Jolla	92037-6233
Jeff	Nichols	North Hollywood	91601
Sharon	Nicodemus	Sacramento	95821-5642
Christina	Nillo	W. Hollywood	90069
K.	Nilsen	Ben Lomond	95005-9311
Dorothy	Nirenstein	Kentfield	94904-2635
Kristin	Niswonger	Bakersfield	93306
Berna	Nitzberg	Aptos	95003-2501
Dennis	Noble	Cobb	95426
Sheree	Noeth	Concord	94518-2679
Katherine	Nolan	Cupertino	95014-2455
James	Noordyk	San Diego	92109-2802
Sonja	Norberg-Sanchez	Carlsbad	92009-8340
Valerie	Nordeman	Laytonville	95454-1715
Kathey	Norton	Sacramento	95831-2338
Donna	Norton	Petaluma	94952-9210
Marjorie	Nothern	Danville	94506-2124
Ursula	Noto	Burbank	91504
Maria	Nowicki	San Francisco	94116-2517
Tom	Nulty Jr	Dana Point	92629-2901

Carlos	Nunez	Reseda	91335
Miriam	Nunez-Valdovinos	Cudahy	90201
Kimberley	Nunn	Napa	94559
Max	Nupen	Irvine	92606-8340
Schani	Nuripour	Los Angeles	90027-5504
Kate	Nyne	Oakland	94601-4354
Wendy	Oakes	San Francisco	94117-1931
Kent	Oberlin	San Marcos	92078
Kathleen	Obre	Laguna Beach	92651-3036
Kathy	Obrien	Redway	95560-2423
Colleen	Obrien	Sacramento	95826
Cihtli	Ocampo	Toluca Lake	91610-0796
April	Ochoa	Santa Rosa	95403-4159
Deborah	O'Connor	Los Angeles	90066-6132
Susan	Ocopnick	Solana Beach	92075
Sharron	O'Donnell	Rocklin	95677-1529
Richard Michael	O'Donnell	La Quinta	92253-8825
Gregg	Oelker	Altadena	91001-4109
Linda	Oeth	Corona Del Mar	92625-2611
Jena	Offield	Laguna Beach	92651
Sujo	Offield	Venice	90291-4248
Dave	Ogilvie	Santa Barbara	93105-3250
William	O'Hare	Daly City	94015-3547
M	Okazaki	San Diego	92121-1808
Sofia	Okolowicz	Temecula	92592-9686
Bill	Oliver	Fairfield	94533
Lynne	Olivier	Richmond	94805-1739
Carol	Oller	Pinole	94564-1813
Kari	Olsen	Soquel	95073-2739
Leah	Olson	San Francisco	94117
Diane	Olson	Santa Monica	90403-1370
Jeffery	Olson	Vista	92084
Krister	Olsson	Los Angeles	90013-2298
Ann-Marie	Olsson	San Francisco	94117-2387
Polly	O'Malley	Los Angeles	90025-3916
Barbara	Oman	Carmel	93923-8806
Chris	OMeara Dietrich	San Jose	95148
Terry	O'Neal-O'Rourke	Ferndale	95536-0571
Cara	O'Neill	Calistoga	94515-9634
Julianna	Onstad	San Diego	92109-2363
Roberta	Orlando	San Francisco	94108
Carole	Ormiston	Sausalito	94965-2120
Karen	Ornelas	San Pedro	90731-2424
Angel	Orona	Alhambra	91803-3440
Karen	Orourke	Canoga Park	91304-1005

Henry	Ortiz	Whittier	90605
Robert	Ortiz	Novato	94945-2610
Ivonne	Ortiz	Dixon	95620
Katharine	Osburn	El Cerrito	94530-1813
Karen	Osgood	Citrus Heights	95611-2335
Maureen	Oshea	San Francisco	94127
Linda	Oster	Escondido	92029-8127
Hillary	Ostrow	Encino	91316-1013
Dianne	Ostrow	Wrightwood	92397-2628
Mary	Ott	Marina Del Rey	90292-6590
Laura	Overmann	Burlingame	94010-5141
Denise	Owens	Burbank	91501-2067
Michael	Ozaki	Huntington Beach	92647
Ron	Packard Jr	Mountain View	94041
Sandi	Packer	San Diego	92130-2832
Melody	Padget	Pine Valley	91962-0855
Nancy	Page	San Luis Obispo	93405-6224
Trisha	Pahmeier	Vista	92084-3236
Anne	Painter	Petaluma	94954
Lorna	Paisley	Van Nuys	91406-4557
Mary	Palacios	San Bernardino	92410-2324
John	Paladin	Valencia	91380
John	Palafoutas	Los Angeles	90038
Beatriz	Pallanes	Santa Ana	92704-3131
Elizabeth	Palmer	San Diego	92142-0065
Allie	Palmer	San Clemente	92672-5140
Robert	Palmer	El Cerrito	94530-2152
Aydee	Palomino	La Quinta	92253
Jim	Panagos	Pasadena	91101-3233
Rosiris	Paniagua	Altadena	91001
Jeff	Pantukhoff	San Clemente	92672-9302
Jessica	Paolini	Valencia	91355-4961
Bhavani	Param	Concord	94518-3821
Neal	Pardee	Los Angeles	90026
Joe	Pardee	Pasadena	91107-3654
Sally	Paris	Walnut Creek	94596-4463
Elaine	Parker	Berkeley	94708-2220
Doug	Parker	Apple Valley	92307-1141
Alex	Parker	San Francisco	94121
Cheryl	Parkins	Oakland	94611-5115
Janet	Parkins	Oakland	94611
April	Parkins	Oakland	94611-5115
Laura	Parks	Santa Cruz	95060
Kayla	Parks	Long Beach	90815-1124
Alison	Parmer	Oakland	94610
Ron	Parsons	South San Francisco	94080-1618

Amy	Parsons	Redwood City	94062-2964
Caesar	Pascual, MSW	Norwalk	90650-2032
Nancy	Paskowitz	Oakland	94609-1746
Daniele	Pasquazzi	San Diego	92122
Dorothy	Pasquinelli	San Mateo	94403-3637
Richard	Patenaude	Hayward	94541-3477
Narendra	Patni	Palo Alto	94306-3609
Lynn	Patra	Redding	96001-0149
Katherine	Patterson	Ukiah	95482-4678
James	Patton	Los Altos	94024-3828
Lisa	Patton	San Francisco	94115-3234
Penn	Patton	Arcadia	91007-6274
Stacy	Patyk	Aptos	95003-4518
David	Paul	Turlock	95380-2838
David	Paulsen	Morro Bay	93442-2302
Melony	Paulson	Diamond Bar	91765-2844
Francis	Payad	San Diego	92121
Amy	Payne	Menlo Park	94025-1804
Karin	Peck	Carmichael	95608-0310
Sarah	Peck	Capitola	95010-1956
Josh	Pederson	Santa Cruz	95060
Michele	Pedrini	Arcadia	91007-6779
Carlos	Peeler	San Francisco	94102-2886
Mitra	Pejman	San Diego	92130-2136
Evelin	Pekin	San Dimas	91773-4308
Jeffrey	Pekrul	San Francisco	94114-1897
Dr Kenneth R	Pelletier	Carmel	93921
Tracy	Pellonari	Santa Rosa	95405-7624
Ralph	Penfield	San Diego	92104-7712
Maree	Penhart	Oxnard	93035-3743
Greg	Pennington	San Francisco	94109-6178
Kenneth	Pennington	Canyon Country	91386
Joanne	Pennington	San Clemente	92672-3368
Linda	Penrose	Morro Bay	93442-3149
Dan	Perdios	Palm Springs	92262-0701
Holly	Perez	Chula Vista	91910
Margarita	Perez	Sylmar	91342-2623
Jana	Perinchief	Sacramento	95821
Hannah	Perkins	Canyon Lake	92587
Janet	Perlman	Berkeley	94705-1052
Martin	Perlmutter	Burbank	91506-2135
Karen	Perry	Yucca Valley	92284-1703
Theresa	Perry	Sunland	91040-1967
Lee	Perry	Watsonville	95076-0514
Marie	Perry	Ceres	95307-4102
Jo Ann	Perryman	Daly City	94015-3436

Deborah	Pesqueira	San Diego	92116-4723
Daniel	Petersen	Claremont	91711-4202
Dawn	Peterson	Santa Rosa	95404-7764
Rachel	Peterson	La Jolla	92037-0922
Peter	Peterson	Walnut Creek	94595-3553
Matthew	Peterson	Winnetka	91306-3529
Kim	Peterson	Cloverdale	95425
John	Petroni	El Cerrito	94530-2824
Peter	Pfeiffer	Altadena	91001-4650
Margaret	Phelps	Los Angeles	90024-6183
Tami	Phelps	Redding	96003-3119
Rajander	Philip	San Diego	92168
Regina	Phillips	Winnetka	91306-3264
Louanna	Phillips	Arcata	95521-6564
Karen	Phillips	Granite Bay	95746-6523
Marvis J.	Phillips	San Francisco	94102-6526
Roxie	Piatigorski	West Sacramento	95605-1709
Jacob	Picheny	Berkeley	94705-2226
Seth	Picker	Diamond Springs	95619-1252
Sherra	Picketts	San Francisco	94123
Lora	Pierce	Sacramento	95835
Fritz	Pinckney	Napa	94558-3756
Annalee	Pineda	San Francisco	94109-5838
Hernan	Pineda	Thousand Oaks	91360-4851
A.	Pinheiro	Pleasanton	94566-5438
Cescilia	Pino	Bellflower	90706
D	Pioli	Burbank	91510
Lynn	Pique	Redwood City	94063-1036
L.	Piquett	Santa Cruz	95063-2751
Charlotte	Pirch	Fountain Valley	92708-5818
Barbara	Piszczek	Oxnard	93036
Polly D	Pitsker	Huntington Beach	92648
Diane	Pitzel	San Diego	92109-3763
Tammy	Plante	Palm Springs	92262-7559
Lauren	Pliska	Laguna Niguel	92677
Joseph	Pluta	Bakersfield	93301-4931
Maria	Pocapalia	Manhattan Beach	90266-2110
William	Pogue	La Mesa	91941
Barbara	Poland	La Crescenta	91214-2007
Mark	Poland	Palmdale	93550-7703
Alice	Polesky	San Francisco	94107
Bret	Polish	Los Angeles	91335
Linda	Pollard	El Segundo	90245-3017
Jeri	Pollock-Leite	Altadena	91001
Jackie	Pomies	San Francisco	94122-1334
Erica	Ponce	Moorpark	93021-2919

Beverly	Poncia	Lower Lake	95457-0971
Kathy	Popoff	San Pedro	90732-2272
Donnal	Poppe	Sherwood Forest	91325-2603
Lyra	Porcasi	Thousand Oaks	91360-2124
Susan	Porter	Pasadena	91103-1445
Donna	Porter	Eureka	95502
Melissa	Porter	San Leandro	94577-3036
P.	Porter	San Francisco	94109-2717
Rick	Posten	Gardena	90247
Matt	Powell	Woodland Hills	91364
Cindy	Powell	Newport Beach	92661-1024
Antonia	Powell	Venice	90291-3641
Jane	Powell	Alamo	94507-1930
Kathleen	Powell	Vallejo	94590-3943
Jessica M	Powell	Fairfax	94930-2033
Judith	Poxon	Sacramento	95816-5250
Linda	Prandi	Sacramento	95834-7519
Wendy	Pratt	Redondo Beach	90277-3009
Joy	Pratt	Somis	93066-9719
Rebecca	Prewitt	North Hollywood	91602-1736
Susan	Price	Simi Valley	93063-3743
Marilyn	Price	Mill Valley	94941-2074
Andrew	Price	Moraga	94556-2363
Rosalie	Prieto	Bakersfield	93311-4529
Menkit	Prince	Carmichael	95608-1705
Alma	Prins	Berkeley	94702-1618
Fiona	Priskich	Swan View	90210
Karen	Privett	Fresno	93720
Maureen	Prochaska	Berkeley	94706-2307
Penelope	Prochazka	Simi Valley	93063-1408
Michelle	Profant	Goleta	93117-2435
Micaela	Pronio	Oakland	94609-1008
Mary	Proteau	Los Angeles	90036
Lois	Pryor	Alameda	94501-1681
Richard	Puaoi	Novato	94949-6627
Felena	Puentes	Bakersfield	93312-5145
Cynthia	Purcell	Woodland Hills	91367-5517
Linda	Pydeski	Placentia	92870-4137
Bonny	Quackenbush	Sacramento	95825-1607
Philip	Quadrini	Sausalito	94965-1030
Karen	Quail	Davis	95616-2667
Robert	Quarrick	Benicia	94510-2911
Jennifer	Quednau	Sherman Oaks	91403-2646
Susan	Quickel	Tracy	95376-1707
Yessenia	Quintero	South Gate	90280-2431
Vanessa	Quintero	Rodeo	94572-1445

Marissa	Quiroz	Irwindale	91706-2110
Michael	R. Watson	Sonoma	95476
Sara	Rabbani	Los Angeles	90024-4436
Sarah	Rabkin	Soquel	95073
Maryann	Rachford, EdD	Temple City	91780
Martha	Rader	Woodland	95776-9362
Lucia	Rael	Sacramento	95826-4568
Lollie	Ragana	Santa Monica	90405-5538
Wadane	Ragland	Elk Grove	95758-7637
Mary	Ragsdale	Ripon	95366-3122
Annette	Raible	Petaluma	94952-9687
Karen	Ramboldt	Santa Clarita	91390-4930
Grace	Ramirez	Eureka	95502-7033
Ileana	Ramirez	Laguna Hills	92653-5653
Monse	Ramirez	South Gate	90280
David	Ramm	Union City	94587-3237
Rudy	Ramp	Arcata	95521-5207
Walter	Ramsey	Oakley	94561-3919
Flo	Randall	Glendale	91205-2087
Dee	Randolph	Chico	95926-5132
Dorri	Raskin	Northridge	91326
Greg	Ratkovsky	Oakland	94619-3111
Karen	Ratzlaff	Santa Rosa	95404-2820
Jenise	Rauser	Bakersfield	93308
Arvind	Ravikumar	Campbell	95011-0026
Deborah	Rawlinson	San Francisco	94109-2661
Cathie	Ray	San Diego	92115-2010
Charles	Ray	San Francisco	94103-1165
Bruce	Raymond	Oceanside	92054-2409
Amira	Rayne	Encinitas	92024
Mike	Real	Newbury Park	91320-3727
Mark	Reback	Los Angeles	90039-3944
Stephanie	Rebolo	Artesia	90701-4212
Verona	Rebow	Arroyo Grande	93420
Maryellen	Redish	Palm Springs	92264-0649
Penny	Redman	Sacramento	95814-6349
Katy	Redmon	Redding	96099-3051
Maryann	Reece	Santa Ynez	93460-9350
Robert	Reed	Laguna Beach	92651-1870
Roberta	Reed	Huntington Beach	92648-4411
Judy	Reens	Brentwood	94513
Catherine	Regan	San Francisco	94116-1843
Karen	Reibstein	San Diego	92120-3108
Susan	Reichert	Torrance	90503-7222
Carl	Reid	Los Angeles	90034-6336
Karen	Reid	Santa Rosa	95403

Matthew	Reid	Calistoga	94515-1737
Rebecca	Reid-Johansson	Fresno	93728-3430
Anne Marie	Reilley	Saint Helena	94574-1510
Judy	Reisberg	Sherman Oaks	91403
Kristen	Renton	Valencia	91354-2524
Matt	Reola	San Clemente	92672-4133
Jonathan	Repreza	Sylmar	91342-1267
Brianna	Rerucha	Costa Mesa	92626
Julia	Ressler	Marina Del Rey	90292
Karin	Rettig	Hemet	92543-2739
F. Carlene	Reuscher	Costa Mesa	92626-4840
Debra L.	Reuter	Martinez	94553-1914
Erich	Rex	San Bruno	94066
Tori	Reyes	Upland	91784-9290
Mike	Reyes	Los Angeles	90035-2305
Christian	Reyes	Moreno Valley	92555
Jim	Reynolds	Montague	96064-9101
Lloyd	Reynolds	Fountain Valley	92708-1145
Margarite	Reynolds	San Francisco	94107-2384
James	Reynolds	Sunland	91040-2417
Joseph	Rhoades	Vacaville	95688-4409
David	Rhoades	Belvedere Tiburon	94920
Mark	Ricci	Point Arena	95468-0972
Jean	Ricci	Novato	94945
Marybeth	Rice	Berkeley	94708-1820
Kim	Richards	Berkeley	94709-1605
Lonna	Richmond	Muir Beach	94965-9754
Lynette	Ridder	Concord	94521-2910
Barbara	Riddle	Redding	96001
Mark	Riddlesperger	Porter Ranch	91326-2142
William	Rietzel	North Hollywood	91601
Sandra	Riley	Claremont	91711
Ronald	Ringler	Long Beach	90815-5127
Ron	Riskin	Santa Barbara	93103-2131
Michaele	Risolia	Livermore	94550-8609
Ciara	Ristig	Santa Barbara	93111-1641
Patricia	Ritter	Sherman Oaks	91423-4227
Briana	Rivera	San Diego	92121-4123
Christine	Rivera	Concord	94521-1505
Tania	Roa	La Mirada	90638-3916
Martin	Robbins	Los Osos	93402-3801
Sallie	Robbins-Druian	Palm Springs	92264
Leonard	Robel	Windsor	95492-0852
Rob	Roberto	Santee	92071-1291
Rachel	Roberts	Tracy	95377
Gail	Roberts	Tecate	91980-0656

Darryl	Roberts	Santa Rosa	95404-9703
Margaret	Roberts	Mendocino	95460
Valeen	Robertson	San Mateo	94403-1457
Chris	Robertson	Los Angeles	90036-4978
Etta	Robin	Bakersfield	9331-2524
Nancy	Robinson	Ridgecrest	93555-3947
Suzanne	Rocca-Butler	Menlo Park	94025-6749
Candace	Rocha	Los Angeles	90032-1308
Maria	Rocha	Oakhurst	93644
Maureen	Roche	Petrolia	95558-0146
Donald	Rock	Oceanside	92054-5516
Phil	Rockey	Aptos	95003-3233
Cheryl	Rockwell	Santa Cruz	95060-2971
Susan	Rockwell	Petaluma	94953-0543
Mary	Rodarte	Phelan	92371
Leslie Ann	Rodarte	Walnut Creek	94597-1904
Terrell	Rodefer	Van Nuys	91405-2797
Colleen	Rodger	El Sobrante	94803-3548
John	Rodgers	Woodland	95776-5477
Sharon	Rodrigues	Fremont	94539-3738
Norma	Rodriguez	Bellflower	90706-7102
Doris	Rodriguez	Ontario	91762-6892
Tommy	Rodriguez	Perris	92570-4514
B.	Rodriguez	Hercules	94547-3640
Jose	Rodriguez	Whittier	90604-3854
Anthony	Rodriguez	Monterey	93940-6879
Erin	Roedeinger	San Diego	92107-5116
Pamela	Rogers	San Bernardino	92404
Ashley	Rogers	Alameda	94501
Stacey	Rohrbaugh	Willits	95490-8722
Mike	Rolbeck	Placerville	95667-7702
Patricia	Rom	Berkeley	94703
Michele	Roma	Concord	94520-3574
Nora	Roman	San Francisco	94110-5913
Valerie	Romero	Quincy	95971-9657
Rob	Rondanini	Roseville	95678-8441
Van	Rookhuyzen	San Francisco	94102
Diane	Rooney	El Cerrito	94530-1964
Irene	Roos	Lakeside	92040-4614
Barbara	Root	Merced	95340-8353
Charlene	Root	Whittier	90602-3321
Greg	Rosas	Castro Valley	94546-3653
Chris	Rose	Petaluma	94952-4839
Tona	Rose	Rancho Murieta	95683-9562
Babette	Rose	San Diego	92127
Sheryl	Rose	Berkeley	94702-1001

Ken	Rosen	Beverly Hills	90212-2275
Amanda	Rosenberg	Oakland	94606-1535
Stephen	Rosenblum	Palo Alto	94301-3939
Robert	Rosenblum	San Diego	92123-3623
Wendy	Rosenfeld	North Hollywood	91601-4472
Howard	Rosenfield	Santa Rosa	95404-9582
Darlene	Ross	Woodbridge	95258-8900
Sara	Ross	Los Angeles	90032-2040
Wilson	Ross	San Francisco	94118-3929
Stephanie	Rossi	Trabuco Canyon	92679-3500
Michael	Rotcher	Mission Viejo	92692-2351
Kristy	Rotermund	Nevada City	95959
John	Rotondi	Oceanside	92056-3015
Consuelo	Rovirosa	West Covina	91790-4405
Erin	Rowe	Arcata	95521-5424
Hildy	Roy	Magalia	95954
Allen	Royer	San Jose	95125-3114
Vickie	Rozell	Menlo Park	94025
Susan	Rubin	Los Angeles	90068-3406
Lisa	Rubin	Huntington Beach	92647
Lois	Ruble	San Marcos	92078
Paula	Rufener	Torrance	90503-7128
Dennis	Ruffer	San Jose	95125-1428
Romie	Ruiz	Los Angeles	90027
Diane	Ruiz	Ventura	93002
Kristen	Rumbaoa	San Leandro	94579-2796
Paul	Runion	Ben Lomond	95005
Kayla	Russick	San Francisco	94117
Robert	Russo	Glendora	91741-0002
Lucymarie	Ruth	Oakland	94610-2803
Brian	Rutkin	Culver City	90230-3741
Susan	Ryan	Los Angeles	90019-1545
Elvia	Ryan	Oceanside	92057-7951
Mary	Ryan	Walnut Creek	94595
Elvia	Ryan	Oceanside	92057-7951
Elizabeth	Ryan	Santa Cruz	95062
Rose	Rygiel	Half Moon Bay	94019-2184
J.B.	Sacks	West Hills	91307
Harry	Saddler	Berkeley	94705-2023
Hannah	Salassi	San Francisco	94116-2646
Alicia	Salazar	Los Angeles	90032-1505
Mariana	Salerno	San Diego	92101-2576
Mario	Salgado	Anaheim	92801-1779
David	Salinas	Castaic	91384-2444
Stephanie	Salter	Los Angeles	90048
Christi	Saltonstall	San Francisco	94114-3615

Jonathan	Sampson	Santa Rosa	95404-2260
Marian	Samson	Danville	94526-1407
Danielle	Samuelson	San Diego	92117-1042
Cheryl	Sanchez	Long Beach	90802-1162
Diana Rose	Sanchez	Fillmore	93015-1950
Tom	Sanchez	Los Angeles	90031
Pamela	Sandberg	Fort Bragg	95437
Charles	Sanders	San Diego	92128-2079
Michele	Sanderson	Walnut Creek	94595-3736
Adrian	Sandoval	Los Angeles	90022
B	Sandow	Richmond	94804-1520
Val	Sanfilippo	San Diego	92111-5057
Ken	Sanford	Escondido	92029
Thekla	Sanford	Buellton	93427
Carol	Sangster	Ojai	93024-0149
Yesenia	Santana	Fremont	94538
Harry	Santi	San Leandro	94579-1239
Sophia	Santitoro	Simi Valley	93065-4300
Alfa	Santos	Chula Vista	91910
Michelle	Santy	El Granada	94018-1540
Slaughter,	Sarah	San Francisco	94114-1507
Natasha	Saravanja	San Francisco	94131-2013
Deborah	Sargent	San Diego	9212826
Sabrina	Sarne	Danville	94526
Vicki	Sarnecki	Bangor	95914-0369
Julie	Sasaoka	Concord	94518-1829
Rondi	Saslow	Oakland	94618-1518
Anna	Sasser	Santa Cruz	95062-2703
Angelina	Saucedo	Montebello	90640-0676
Benjamin	Sawyer-Long	Pleasanton	94566-6887
Jana	Scalzitti	Los Angeles	90048-2405
Kevin	Schader	Pleasant Hill	94523-1370
Ellen	Schaffer	Sherman Oaks	91403-4205
Roberta	Schear	Oakland	94618
Douglas	Scheel	Los Osos	93402-2718
Janice	Schenfisch	Moorpark	93021-1541
Barbara	Schenk	Beverly Hills	90212-4402
Susanne	Schieffer	Thousand Oaks	91360-1217
Bob	Schildgen	Berkeley	94703-1630
Esther	Schiller	Newbury Park	91320-4804
Steven	Schlam	San Diego	92104
Denise	Schlatter	Northridge	91327-7848
Patti	Schlenker	Sacramento	95828-4639
William	Schlesinger	Los Angeles	90046-6810
Heather	Schlichter	Woodland Hills	91364-5915
Henry	Schlinger	Glendale	91201-1278

Arne	Schmidt	Santa Barbara	93101-4937
Lucy	Schmidt	Simi Valley	93063-3702
Patrick	Schmitz	Oakland	94609
George	Schneider	San Diego	92105
Lauren	Schneider	Los Angeles	90068-3620
Andrea	Schneider	Glendora	91741-2710
William	Schoene	Santa Monica	90405-4847
Maria	Schoettler	Oakland	94609
Anna	Schofield	Los Angeles	90024-4838
Sidney	Scholl	Glen Ellen	95442
Heather	Schraeder	Culver City	90230-4274
Laura	Schuman	Sherman Oaks	91403-4239
Jeanne	Schuster	West Covina	91791-3531
Lester	Schwabe	Monterey	939-4022
Bruce	Schwagerl	San Diego	92104-2781
Don	Schwartz	Larkspur	94939-1264
Barry	Schwartz	Napa	94559-3203
Sally	Schwartz	Petaluma	94952
Marge	Schwartz	Santa Barbara	93121-1955
Patricia	Schwarz	El Cerrito	94530-2216
Dena	Schwimmer	Los Angeles	90019-2407
Pamela	Scott	Boulder Creek	95006-8543
Kari Lorraine	Scott	San Diego	92116
Celia	Scott	Santa Cruz	95060
Bruce	Scott	Pacific Palisades	90272-3628
Aimee	Scott	Sherman Oaks	91401-4921
Pamela	Scrape	Pasadena	91101-2451
P	Seag	Inglewood	90309
Andrew	Seagraves	Antioch	94531-7717
Ron	Season	Calabasas	91302-5157
Chris	Seaton	Santa Barbara	93101-4651
David	Sedeno	Bakersfield	93307
John	Sefton	Trabuco Canyon	92678-0714
Ellen	Segale	Rohnert Park	94928-2572
Harold	Segelstad	Woodside	94062-4728
Lisa	Segnitz	Santa Cruz	95060-3433
Mary Jill	Seibel	Petaluma	94952-9623
Karin	Seid	Oakland	94618
Fredrick	Seil	Berkeley	94708
Rob	Seltzer	Malibu	90265-5630
Ronald	Semenza	San Jose	95119-1516
Ellen	Sennewald	Sebastopol	954720
Jon	Senour	San Diego	92109-1711
Lynn	Sentenn	Brea	92821
Michelle	Seymoure	Whittier	90601-2321
Marguerite	Sgrillo	Richmond	94896

Janette	Shablow	Oceano	93475-0233
Susan	Shackman	Santa Cruz	95060-4230
Linda	Shadle	Anaheim	92804-5257
Brooke	Shaffer	Hesperia	92345-4806
Karin	Shaffer	San Marcos	92069
Mariam	Shah-Rais	Redondo Beach	90277-4302
Marcia	Shakman	Canyon Country	91351-1027
Victoria	Shankling	Aliso Viejo	92656-8040
Kaelan	Shannon	Corona	92882
Susie	Shapira	San Rafael	94901
Michael	Shapiro	Goleta	93117-1305
Julie	Shaw	Sebastopol	95472-5142
Alexandria	Shearer	Buena Park	90621
Aaron	Sheiman	Sacramento	95864-7261
Marilyn	Shepherd	Trinidad	95570-0715
Lisa	Sherman	Berkeley	94705-2354
Roberta	Shirer	Carmichael	95608-1076
Zoa	Shoats	Pacific Grove	93950-5222
Lula	Shoberg	San Jose	95116-1526
Kayla	Shoemaker	Anaheim	92806
Ari	Shofet	Los Angeles	90036-2926
Jessie	Shohara	Kensington	94708-1032
Tracy	Shortle-Turner	Los Alamitos	90720-5243
Rick	Shreve	Weott	95571-0011
Lois	Shubert	Camarillo	93010-3036
Joseph	Shulman	San Diego	92115-6932
Lauren	Siadek	Hawthorne	90250-5619
Nancy	Sidebotham	Oakland	94605
Gayle	Sides	Carlsbad	92008-4308
Pamela	Sieck	Belvedere Tiburon	94920-1452
Martha	Siegel	Santa Barbara	93105-5424
Joyce	Siegling	Pleasanton	94566-5337
D.G.	Sifuentes	Mammoth Lakes	93546-0100
Sheila	Silan	Somerset	95684-9280
Uly	Silkey	Oakland	94602
Dan	Silver	Los Angeles	90012-2584
Victoria	Silver	Irvine	92617
Darcy	Silver	Calabasas	91302-2815
Marc	Silverman	Los Angeles	90068-3071
Katherine	Silvey	Martinez	94553-5344
Kathy	Simington	Ontario	91764-2721
Rebekah	Simmers	Antioch	94509
Claire	Simonich	Half Moon Bay	94019
Kim	Simpson	Venice	90291
Deborah	Sinclair	Los Angeles	90042

Charlotte	Sines	Yosemite National Park	95389-2203
Randle	Sink	Huntington Beach	92649-3810
Lyn	Sinko	Menlo Park	94025-6039
Sarah	Sismondo	Duarte	91010-2186
Joan	Sitnick	Encino	91436
Michael	Sixtus	Santee	92071-2252
Steve	Sketo	Bakersfield	93312
Sierra	Skinner	Santa Maria	93455
Kimberly	Skuster	San Diego	92128-5163
Kevin	Slauson	Alameda	94501
Cathy	Sleva	Seal Beach	90740-6507
Lindley	Sloan	Monterey	93940-6301
Susan	Sloan	Los Angeles	90064-2679
Leslie	Sloane	Oak Park	91377-5419
Kimberly	Smiley	Castaic	91384-3184
Lisa J	Smirnov	Desert Hot Springs	92241-9358
Judith	Smith	Oakland	94601
Joan	Smith	Greenbrae	94904-1316
Bret	Smith	Santa Cruz	95063-2824
Julie	Smith	Los Osos	93402-4006
Cynthia	Smith	Mission Viejo	92691-3250
Missie	Smith	Tehachapi	93561-6840
Nancy	Smith	San Diego	92106-2743
Susan	Smith	Pollock Pines	95726-9538
Yvonne	Smith	Upland	91784
West	Smith	Ojai	93023
Sandy	Smith	Sebastopol	95472-0186
Richard	Smith	Aptos	95003-4517
Christine	Smith	Chino	91710-6202
Lance	Smith	Long Beach	90803
Karin	Smith	Chico	95928
Ruth	Smith	Chico	95928
Anthony	Smith	Newcastle	95658
Avigal	Snapir	Los Angeles	90025-3629
Dolores	Snell	Trinidad	95570
Tower	Snow	Calistoga	94515-9406
Joanne	Snyder	San Diego	92123-3619
Todd	Snyder	San Francisco	94115
David	Soares	Pollock Pines	95726-9424
Faye	Soares	Pollock Pines	95726-9424
Sue	Soh	Woodland Hills	91367-1015
Jessica	Sohi	Atascadero	93422-6207
Diana	Solomon	Culver City	90230-4226
Kristi	Somers-Kawas	Porter Ranch	91326-1121
Karen	Sommer	Smith River	95567

Michael	Song	San Jose	95118-1625
Monica	Soto	San Bernardino	92407-6108
Rob	Soule	San Francisco	94103
John	Southward	Lakewood	90712-1305
Katherine	Spahn	Lakewood	90712-3952
Linda	Spanski	Oceanside	92054-6536
Jack	Sparks	San Bruno	94066
A	Sparks	Castro Valley	94546-2878
Laurie	Sparrow-Price	Martinez	94553-2922
Barbara	Speidel	La Mesa	91942-2611
D R	Spencer	San Diego	92104-4645
Brent	Spencer	Long Beach	90808-4105
Raymond	Spencer	Bodega Bay	94923
Anne	Spesick	Auburn	95604-7367
Jane	Spini	Arcata	95521-8976
Nancy	Spittler	Lafayette	94549-3206
Sara	Spohr	San Diego	92111
Leslie	Spoon	Los Osos	93402-1863
Natalia	Spornik	Studio City	91604-2867
Michael	Spratt	Grass Valle	95945
Christine	Springett	Santa Monica	90405-5437
Cathy	Springs	San Diego	92129-1205
Wendy	Springstead	San Rafael	94901-1010
Joan	Squires	Oceanside	92057-8309
A.	Srinivasan	Altadena	91001-3768
Debbie	St John	Tujunga	91042-1101
Andy	St Laurent	San Juan Capistrano	92675-2240
Janaka	Stagnaro	Carmel Valley	93924-9646
Bettina	Staib	Los Angeles	90019
James	Stamos	Saratoga	95070
Rachel	Standish	Stockton	95204-5910
Marilyn	Standley	Sebastopol	95473-2327
Mark	Standon	San Bernardino	92407
Lisa	Stanley	North Hollywood	91601-4026
Erica	Stanojevic	Santa Cruz	95060-6007
Neil	Stanton	Chula Vista	91910-2425
Morning	Star	Long Beach	90813-2217
Jan	Stark	Westminster	92683-5831
Rebecca	Starr	Fresno	93703
Celia	Stauty	Pacific Grove	93950-2821
Patricia	Stearns	Exeter	93221-9793
Karen	Steele	Eureka	95501
Regina	Stefaniak	Berkeley	94708 1902
Wayne	Steffes	Redding	96001-2906
Richard	Steiger	Oakland	94611
Cindy	Stein	Thousand Oaks	91360

Karl	Steinberg	Newport Beach	92663-4023
Neal	Steiner	Los Angeles	90034
A.L.	Steiner	Los Angeles	90063
Sofia	Steinhagen	Healdsburg	95448-4306
Judith	Steinhart	Palo Alto	94301-3302
George	Steinitz	Campo	91906
Therese	Steinlauf	Los Angeles	90024-6021
Kat	Stephens	Santa Rosa	95409-6220
Burney	Stephens	Mariposa	95338
Shelley	Sterrett	Santa Monica	90402-1559
Bob	Stevens	Redondo Beach	90277-6853
Christina	Stevens	Malibu	90265
Thomas	Stevens	Walnut Creek	94595
Christine	Stewart	Escondido	92026-1461
Michael	Stewart	Elk Grove	95624-2729
Michele	Stewart	San Diego	92128-5198
Eric	Stiff	Los Alamos	93440
Bonnie	Stillwater	Los Angeles	90020-3003
Phil	Stillwell	Monrovia	91016-4332
Carl	Stilwell	Pasadena	91106
David	Stobie	Los Angeles	90210
Steve	Stone	Los Angeles	90063-1602
Peggy	Stone	San Diego	92101-6736
Mika	Stonehawk	Tustin	92782-8008
Tobi	Stonich	Santa Cruz	95062-5554
Carol	Stormberg	San Jose	95129
Phil	Stotts	Capitola	95010-3040
Virginia	Stovall	Vallejo	94590-4712
Tara	Strand	North Hollywood	91601
Ann	Stratten	La Mesa	91941-7325
Terry	Strauss	Mill Valley	94941-2193
M	Straw	Los Angeles	90028-4953
Ellen	Straw	Covina	91722-1409
Marjorie	Streeter	Sacramento	95816
Janelle	Streich	Gualala	95445
Kathy	Strijek	Palm Springs	92262-1237
Cedric	Stroehnisch	Reseda	91335-2225
Todd	Struthers	Pleasant Hill	94523-3007
Sarah	Stryhanyn	Emeryville	94608-2423
Teresa	Stuefloten	San Jose	95123-5352
Linda	Sturges	Glendale	91202
Debbie	Sturt	Marina	93933-3503
Carey	Suckow	San Francisco	94114-1618
Teresa	Sullivan	Los Angeles	90065-1727
Amy	Sullivan	Los Angeles	90066
Edward	Sullivan	San Francisco	94116-2077

Kaytee	Sumida	San Diego	92120-1333
Freddie	Sumilhig	Yuba City	95991
Paula	Summers	Fair Oaks	95628-4033
Lynn	Sunday	Half Moon Bay	94019
Stacie	Surabian	Los Angeles	90068-3038
James	Surtees	North Hollywood	91602-1260
Hugh	Sutherland	Goleta	93117-8003
Ellyn	Sutton	Simi Valley	93094-0884
Jane	Sutton	La Jolla	92037-3905
Julie	Svendsen	Burbank	91505-3837
Mariano	Svidler	San Mateo	94403-3201
Cate	Swan	Monte Rio	95462
Rebecca	Swanson	Mariposa	95338-9772
Roberta	Swanson	Walnut	91789-2706
Carrie	Swanson	Costa Mesa	92627
Jay	Swanson	West Sacramento	95691
Debra	Swartz	Los Angeles	90034-5430
Pat	Sweem	Santa Barbara	93108-2510
Patricia	Sweet	San Francisco	94116-1049
Christine	Swenning	Richmond	94805-0329
Patrick	Swift	Fresno	93710
David	Swire	Simi Valley	93063
Joseph	Szabo	Los Angeles	90045-4332
Jim	Szewczak	Redwood City	94062-0313
Karen	Taatjes	Lompoc	93436-1117
Linda	Tabb	North Hills	91343-3720
Tyra	Tabor	Reseda	91335-1124
Janet	Tache	Penn Valley	95946-9394
Barbara	Tacker	Camarillo	93012-7715
Kathleen	Taggart	Palm Springs	92264
Trina	Takahashi	Brentwood	94513-6154
Jeremy	Talarico	Concord	94521
Nawal	Tamimi	Richmond	94804
Susan	Tamura	San Diego	92129-3362
Binh	Tang	Chatsworth	91311
Carrie	Tanke	Moorpark	93021
Tina	Tanner	Placerville	95667
Carol	Tao	Salinas	93901
Eveline	Tapp	San Francisco	94111-1032
Peter	Tarantino	San Diego	92124
Fred	Tashima	Los Angeles	90066-4914
Tom	Tataranowicz	Malibu	90265-3041
Katie	Tatro	Sunnyvale	94087-3344
Susan	Tatro	Eureka	95503-4814
Georgia	Tattu	Hermosa Beach	90254-2639
Tammy	Taunt	Oceanside	92057-4263

Donald	Taylor	Fair Oaks	95628
Elaine	Taylor	Glendale	91205-3742
Carol	Taylor	Ojai	93023-3055
Tanya	Taylor	Santa Cruz	95060-5846
Pat	Taylor	Sacramento	95814
Edward	Taylor	Grass Valley	95945-4320
Glen	Taysom	Roseville	95747-5824
Alexander	Tchick	Pacific Grove	93950
John	Teevan	Chula Vista	91914-2504
Gerald	Telep	Rancho Cordova	95742-7766
Susan	Telese	Los Angeles	90027-3627
Ad	Telford	Berkeley	94708-2149
Deborah	Temple	San Rafael	94901-1787
Peter	Temple	Albion	95410-0091
Sandy	Templin	Cameron Park	95682-4113
Rick	Ten Eyck	Borrego Springs	92004-0277
Kendal	Ten Have-Kurata	Torrance	90503
Debbie	Tenenbaum	Berkeley	94703-1375
Joanne	Tenney	Escondido	92026-1930
Lisa	Tenorio	Concord	94520-3565
Alex	Terseleer	San Francisco	94110
Troy	Tessalone	Redondo Beach	90277
Charles	Tetoni	Santa Barbara	93103-2214
Jaden	Thigpen	Stockton	95205
Celia	Thilgen	Foothill Ranch	92610
Rita	Thio	Walnut	91789-4104
Julia	Thomas	Portola Valley	94028-7734
Shakayla	Thomas	Compton	90220-2645
Eva	Thomas	Woodside	94062-4307
Lori	Thomas	Poway	92064
Suzanne	Thomas	Pebble Beach	93953-3218
Paula	Thompson	San Diego	92117-5855
Geraldine	Thompson	San Jose	95124-1903
Ronald	Thompson	Crescent City	95531-8103
Carla	Thompson	Ventura	93003-5513
Spencer	Thompson	Campbell	95008
Nancy	Thomsen	Napa	94559-4715
Lynn	Thorensen	Santa Cruz	95060
Cathy	Thornburn	Los Angeles	90041-1128
Robert	Thornhill	Livermore	94550-4109
Russell	Thorp	Novato	94949-6494
Ann	Thryft	Boulder Creek	95006
Kimberley	Thure	Van Nuys	91406
Nan	Thurgate	Soquel	95073-2052
Laura	Ticciati	Redwood City	94063-1799
Kellyn	Timmerman	San Diego	92108-1435

Phyris	Tobler	Rohnert Park	94928-3964
Kalita	Todd	Grass Valley	95945-7956
Michael	Tomczyszyn	San Francisco	94132-3140
Nancy	Tompkins	San Francisco	94110
Andy	Tomsky	San Marcos	92079-0683
Eileen	Tonzi	Galt	95632-0403
Michele	Tornabene	Summerland	93067-1483
Myra	Toth	Ojai	93023
Theresa	Tourigny	San Diego	92128
Marilyn	Tovar	Stockton	95210
Sarah	Townsend	Santa Clara	95050
Candice	Toyoda	El Cerrito	94530-3254
Karen	Toyohara	La Mesa	91941
Rich	Toyon	La Crescenta	91214
Angela	Tran	Trabuco Canyon	92679-4131
Quang	Tran	San Jose	95122-2218
Kate	Transchel	Chico	95926
Beti Webb	Trauth	Eureka	95503-4749
Linda	Trevillian	Alhambra	91803-3727
Charles	Tribbey	San Luis Obispo	93405
Billy	Trice Jr.	Oakland	94621-2825
Tia	Triplett	Los Angeles	90066-5015
Camina	Tripodi	Santa Maria	93454-4512
Martin	Tripp	Santa Clarita	91390-3100
Christine	Troche	Fremont	94555
Veronica	Tucker	Santa Monica	90405-4221
Duane	Tucker	Palm Springs	92262-7913
Anne	Tuddenham	El Cerrito	94530-2550
Russell	Tunder	Woodacre	94973-0882
R.G.	Tuomi	Thousand Oaks	91362
Joy	Turlo	Redondo Beach	90277
Sherri	Turner	Newport Beach	92663-2109
Lucia	Turner	Canyon Lake	92587-7701
Virginia	Turner	Woodland Hills	91367-6141
Alice	Turney	San Jose	95123-4344
Cynthia	Tuthill	St Helena	94574
Natascha	Tuznik	West Sacramento	95691-5462
Glen A	Twombly	Arcata	95521-4523
Steve	Tyndall	San Diego	92111-7846
Kathleen	Tyson	Riverside	92501-2861
Orlonda	Uffre	Piedmont	94620-0036
Patricia	Ulloa	Pasadena	91105-5209
Erik	Ulman	San Francisco	94117-4058
Linda	Ulvaeus	Santa Barbara	93109
Robert	Underwood	Concord	94519-2002
Ray	Uriarte	Murrieta	92562

Martha	Uribe	Yucaipa	92399
Sylvia	Vairo	Santa Cruz	95062-4416
Deborah	Valdez	Ojai	93023
Antonio	Valdez	Anaheim	92801
Albert	Valencia	Huntington Beach	92647-2802
Kimberly	Valentine	Carson	90745-4441
Karen	Valentine	Soquel	95073-9689
Jay	Van Arsdale	Oakland	94605-2505
Kathleen	Van Every	Atascadero	93422-4916
Earl	Van Fleet	Cayucos	93430-1503
Richard	Van Heertum	North Hollywood	91601-2733
Shana	Van Meter	Irvine	92623-6904
Maureen	Vanderbosch	Laguna Niguel	92677
Denise	Vandermeer	Woodland Hills	91367
Shellie	Vann-Volk	Chico	95926
Nagisa	Vanvliet	Livermore	94551
John	Varga	Huntington Beach	92648-5326
Frank	Vargas	Ione	95640-9665
Melissa	Vasconcellos	Ventura	93006-7564
Silvia	Vasquez	Sacramento	95841-2308
Sherry	Vatter	Los Angeles	90034-8105
Iris	Vaughan	San Francisco	94102-6224
Bobby	Vaughn Jr.	Costa Mesa	92626
Valerie	Velazquez	Oxnard	93036-5347
Amy	Veloz	Van Nuys	91406-4344
Dirk	Verbeuren	Valley Village	91607-1615
Shellie	Vermeer	Laguna Hills	92653-4481
Dalia	Vernikovsky	Union City	94587
Paul	Vesper	Berkeley	94703-1237
Lori	Vest	Potter Valley	95469-9736
Marc	Vezian	San Jose	95132-2073
Steve	Vicuna	Monterey Park	91754
Regina	Vidal	Fresno	93726-0919
Seb	Villani	Chula Vista	91912-1754
Pam	Vincent	Richmond	94804-1517
Patricia	Virzi	Jurupa Valley	92509-2849
Nichelle	Virzi	Jurupa Valley	92509-2849
Carlene	Visperas	Concord	94521-1502
Randy	Vitto	Simi Valley	93065-4839
Nathan	Vogel	San Francisco	94117-3110
Mary	Vogt	Grass Valley	95945-6332
Pablo	Voitzuk	Oakland	94618-1745
Melanie	Vollbrecht	Moorpark	93021-2566
Alexander	Vollmer	San Rafael	94901
Ulrike	Vom Stein	Santa Rosa	95405-8685
Susan	Von Schmacht	Watsonville	95076-1047

Kay	Von Tress	Menlo Park	94025-3618
Carol	Vonsederholm	Chula Vista	91913
Roger	Vortman	Santa Cruz	95060
Robin	Vosburg	Bakersfield	93308-1760
Anne	Vosler	San Anselmo	94960-1132
Deborah	Votek	Glen Ellen	95442-0998
Kuniko	Vroman	Los Angeles	9004-1436
Victor	Vuyas	San Francisco	94109-2704
Donna J	Wagner	Pacifica	94044-2532
Inge	Wagner	Los Angeles	90020-2055
Jennifer	Wagner	Fullerton	92831-4429
Karen	Waldear	Sheep Ranch	95246-9591
Sam	Waldman	Mendocino	95460-0049
Kelly	Waldo	Pacific Grove	93950-3833
Morgan	Waldroup	Redding	96001
Mark	Walker	Granite Bay	95746-6278
Laura	Walker	San Francisco	94112-2712
Mitch	Walker	San Diego	92103
James	Walker	Mckinleyville	95519-3854
Robert S	Walker Iii	Nevada City	95959-1948
Barry	Wallace	Highland	92346
Melanie	Wallace	Sacramento	95822-3118
Dianna	Wallace	Lake Isabella	93240-9505
Karina	Walsh	San Diego	92115-2010
Ernie	Walters	Union City	94587-4331
Steve	Walters	San Diego	92117-1111
Ernie	Walters	Union City	94587
Ivonne	Walters	Redlands	92374
Natalie	Wampler	Santa Monica	90404-3404
Rebecca	Wang	Alhambra	91801-6817
Christopher	Ware	Fremont	94539-6850
Charles	Warner	Fontana	92337-0433
Katharine	Warner	Sunland	91040-2625
Lizann	Warner	Fontana	92336-3267
Diana	Waters	Redondo Beach	90277-5280
Melissa	Waters	Laguna Niguel	92677-1447
Anita	Watkins	Oakland	94611-2404
Richard	Watson	Long Beach	90807-1203
Mimi	Watson	San Anselmo	94960-1466
Susan	Watts	Riverside	92506-5843
Carol	Watts	Placentia	92870-6026
Katharine	Waugh	Sacramento	95825-6640
Cheryl	Weatherford	La Jolla	92037-7136
Sally	Webb	Santa Barbara	93108
Anthony	Webb	La Honda	94020-0012
John	Webb	Arcata	95521-4649

Charles	Weber	Oceanside	92056-3933
Sharon	Webster	Huntington Beach	92649-3607
Thomas	Weeks	Lodi	95240-0409
Vicki	Wegscheider-Kissinger	Pollock Pines	95726-9517
Dave	Weidling	Arcata	95521
Gwen	Weil	Oakland	94610-1138
Ashley	Weil	Santa Cruz	95060-5934
Margaret	Weimer	San Mateo	94403-3339
Colette	Weintraub	Santa Monica	90405
Barry	Weinzveg	Petaluma	94952-9735
Joe	Weis	Reedley	93654-2742
Rita	Weisheit	Manhattan Beach	90266-2733
Lynne	Weiske	Los Angeles	90048-5106
Russell	Weisz	Santa Cruz	95060-6109
Michael	Welch	Vacaville	95688-9257
R	Wells	Los Angeles	90020-2727
Jeff	Wells	San Diego	92176-1203
Sharon	Wells	Los Angeles	90066-4919
Margaret	Wessels	Aptos	95003-5927
Heath	West	Los Angeles	90036
Juanita	Westberg	Hesperia	92345
Jan	Wheadon	Napa	94558
Don	Wheaton	Vallejo	94591-6387
Susan	Wheaton	Napa	94558-5881
S	Wheeler	San Francisco	94123
Carolyn	Wheeler	Fremont	94538
April	Wheeler	San Diego	92117-2507
Brandon	Wheelock	Vista	92081-6829
Michael	Whicker	Sacramento	95814
Ronald	Whiles	Canyon Lake	92587-7587
Howard J	Whitaker	Gold River	95670-8301
Bruce	White	Scotts Valley	95067-6616
Phyllis	White	El Dorado Hills	95762-4237
Sara	White	Redlands	92374
Frances	Whiteside	Montclair	91763-2551
Valarie	Whiting	Laguna Beach	92652-7437
Kim	Whitmyre	Long Beach	90804
Irene	Whitney-Simonson	Sacramento	95825-1122
Helene	Whitson	Berkeley	94709
Paul	Whitson	Marina	93933-4954
Barbara	Whyman	Ventura	93001-2155
Chuck	Wieland	San Ramon	94583-1683
Richard	Wightman	Arcadia	91006-2501
Stephanie	Wilder	Mount Shasta	96067-2629

Carol	Wiley	Victorville	92394-1383
Gillian	Wilkerson	Mill Valley	94941-6011
Daniel	Wilkinson	Long Beach	90808-1716
Judy	Wilkinson	La Jolla	92037
Jennifer	Will	Morgan Hill	95037-6064
Mary	Willcutt	Eureka	95503-6674
Judy	Willhoite	Coalinga	93210-1420
Sandy	Williams	Covina	91723-3167
Marina	Williams	San Jose	95125
Debbie	Williams	Sun City	92586
Cassandra	Williams	Brawley	92227-2736
Charlotte	Williams	Inglewood	90302-7165
Sandy	Williams	Santa Cruz	95062
Ty	Williams	San Pedro	90731-5324
Shawn	Williamson	Studio City	91604-1654
Kiyoshi	Williamson	Fairfield	94533-3921
Jean	Williamson	Studio City	91604
William	Willis	Fallbrook	92028-3420
John	Wills	Oakland	94603-3612
Norm	Wilmes	Yuba City	95991
Rick	Wilson	Oceanside	92054-2267
Amy	Wilson	San Mateo	94401-1213
Jim	Wilson	Placerville	95667-7915
Sandra	Wilson	Clayton	94517
Annette	Wilson	Healdsburg	95448-9131
Nichelle	Winchester	Lakeport	95453-4923
Joshua	Wines	Whittier	90606-3232
Marion	Winkler	Sherman Oaks	91423
Lisa	Winningham	Los Gatos	95032-3839
Leslie	Winston	Redondo Beach	90278
Leslie	Winston	Redondo Beach	90278
Anita	Wisch	Valencia	91355
Anita	Wisch	Valencia	91355-3814
Beverly	Witchner	Albion	95410-0610
Rachel	Wolf	Santa Cruz	95060-2244
A.	Wolf	Cardiff	92007
Amy	Wolfberg	Los Angeles	90046
Charles	Wolfe	Sylmar	91342
Alan	Wolfe	San Francisco	94117
Pat	Wolff	Arcadia	91006
Jeffrey	Womble	Lodi	95240-6810
Kathleen	Wong	El Cerrito	94530-2237
Sherard	Wood	Dublin	94568-2324
Suzanne	Wood	Auburn	95603-5504
Jud	Woodard	Sutter Creek	95685-9632
Bill	Woodbridge	Santa Barbara	93111-2020

Peg	Woodin	Oroville	95966-6310
Sharlotte	Woods	Kingsburg	93631-9234
Linda	Woodward	Pleasant Hill	94523-3266
Ann	Wooley	Los Angeles	90024-4300
Ronald	Woolford	Placerville	95667-5816
Moriah	Woolworth	Cupertino	95014-3269
Sharon	Wormhoudt	Loma Mar	94021-9711
Nina	Wouk	Redwood City	94063-2754
Steve	Wozniak	Encinitas	92024
Kenneth	Wright	Santa Rosa	954033-1736
Elizabeth	Wright	San Francisco	94110-3828
Kerry	Wright	Sacramento	95819-2245
Edmund	Wright	Mckinleyville	95519-3924
Mclean	Wright	Sierra Madre	91024-2387
Blake	Wu	Lafayette	94549-3503
Dana	Wullenwaber	Redding	96001-2609
Aimee	Wyatt	Redondo Beach	90277-3507
Caitlin	Wylde	Los Angeles	90026-2625
June	Yamada	Westminster	92683
Alan	Yamamoto	Newhall	91321-2247
Lauren	Yang	Rancho Palos Verdes	90275-5720
Michael	Yankaus	San Jose	95117
Leyza	Yardley	San Mateo	94402-0048
Teri	Yazdi	San Carlos	94070-2812
C.	Yee	Sacramento	95822-0787
Kathy	Yeomans	Ventura	93001-1445
Leanne	Yerby	Irvine	92614
Lisa	Yerington	Escondido	92027-1632
Amanda	Young	Lake Forest	92630
Jo Ellen	Young	Culver City	90230-4113
Savannah	Young	Rancho Cucamonga	91730-3951
Noah	Youngelson	Los Angeles	90066-4134
Christopher	Yrarrazaval	Santa Ana	92706-2528
Katie	Yu	Ladera Ranch	92694
Brian	Yu	Santa Monica	90404-2692
Sophia	Yu	Los Angeles	90004-3181
J	Yudell	Santa Monica	90409-5114
Kathryn	Yulish	Oxnard	93035-4346
Rene	Yung	San Francisco	94131
Thomas	Zachary	La Crescenta	91214-3506
Michael	Zagaris	San Francisco	94117-4011
Guy	Zahller	Aptos	95003-4577
Ann	Zahner	La Jolla	92037-7525
Mary	Zamagni	Valley Springs	95252-9232
Rena	Zaman-Zade	Escondido	92027-3408
Charlene	Zanella	Redwood Valley	95470

Sandra	Zaninovich	Los Angeles	90024-5892
Mark	Zeljak	San Jose	95118
Helen	Zeller	Mission Viejo	92691
Rudy	Zeller	Benicia	94510-1434
Paula	Zerzan	Sonoma	95476-7250
R.	Zierikzee	San Francisco	94118-2520
Pam	Zimmerman	Santa Rosa	95404
Helene	Zimmerman	Santa Monica	90401-2911
Amy	Zink	Oakland	94606-1167
William	Zoller	Trinidad	95570-1132
Susan	Zollinger	La Crescenta	91224-0946
Ronnie	Zuckerberg	San Francisco	94131-2712
Martha	Zuniga	Santa Cruz	95064
Sandra	Zwemke	Los Gatos	95033-8514
Maxine	Zylberberg	San Francisco	94110-1109

west marin environmental action committee

September 26, 2019

California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090
Via electronic delivery to: fgc@fgc.ca.gov

Re: Comments on FGC Agenda Items 17 & 18
Pacific Herring FMP & Regulations

Dear Commissioners,

The Environmental Action Committee of West Marin (EAC) is based in Point Reyes Station and has been working to protect the unique lands, waters, and biodiversity of West Marin since 1971. Since our inception, we have been committed to the health of Tomales Bay. We submitted comments in regard to the Draft Pacific Herring Fishery Management Plan (Herring FMP), specifically as it relates to Tomales Bay on August 1, 2019. We also submitted comments to the Department of Fish and Wildlife (Department) regarding the Herring FMP scoping on September 20, 2018. This comment letter supplements our prior comments, as well as including additional information and comments on the implementing regulations. We thank you for the opportunity to comment on the Herring FMP and its implementing regulations.

Regarding the Herring FMP, we reiterate our past comments that 1) we support the updated recreational limit, and 2) while we support the overall management goals of the Herring FMP, we recommend that commercial fishing be closed in Tomales Bay until further research and monitoring is conducted.

Environmental Action Committee of West Marin | PO Box 609, Point Reyes Station, CA 94956
415-663-9312 | admin@eacmarin.org | www.eacmarin.org

We also supplement our past comments on the Herring FMP with new comments on the recreational take of roe in Tomales Bay. It is our recommendation that the recreational take of roe should be prohibited in Tomales Bay, due to the sensitive nature of the eco-system.

***7.8.7 – Recreational Fishery*: Support Daily Bag Limit**

As we stated in our August 1, 2019 comment letter, we support the Herring FMP's daily bag limit of two 5-gallon buckets of Pacific Herring, *Clupea pallasii*, (Herring). As additional support for the reduced daily bag limit, we add that the unauthorized commercial take in other areas of the state supports the need for a reduced bag limit, as is stated in the Herring FMP.[1]

Recommendation to Close Tomales Bay Commercial Herring Fishery

We reiterate our recommendation for a proposed closure of the commercial Herring fishery in Tomales Bay, due to a number of factors including low Herring numbers, environmental considerations including Herring's important role as a forage fish, lack of commercial interest, high operating costs, lack of infrastructure, and poor market conditions. Herring is a very important forage species for the Tomales Bay eco-system, as is indicated by Dr. John Kelly's recent paper[2] which documented positive, multi-year impacts of strong Herring runs on wintering waterbird populations within Tomales Bay. Regarding the market conditions, a recent Bay Nature article states that the former Japanese market has collapsed with no local market to replace it.[3] Also problematic, Herring face many threats, as is stated in a 2014 report by The Nature Conservancy and Pacific Marine & Estuarine Fish Habitat Partnership:

> Pacific herring face many threats…that range from natural predation (Schweigert et al. 2010), excessive fishing (McKechnie et al. 2014), disease (Marty et al. 2003), habitat loss (Kimmerer 2002, Penttila 2007) and pollution effects (West et al. 2008, Incardona et al. 2012). Much research on threats to Pacific herring focuses on their egg and larval stages because these early life history stages are currently the most exploited and have strong associations with specific benthic habitats.[4]

This report discusses the need for additional research on vegetation and Herring spawning.[5]

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[1] California Department of Fish & Wildlife, *Pacific Herring FMP*, October 2019, page vi.
[2] John P. Kelly, *et al.*, *Echoes of Numerical Dependence: Responses of Wintering Waterbirds to Pacific Herring Spawns*, Marine Ecology Progress Series, June 11, 2018.
[3] Eric Simons, Bay Nature, *A New Plan for Saving the Bay's Recently Thriving Herring*, August 27, 2019, *available at*: https://baynature.org/2019/08/27/a-new-plan-for-saving-the-bays-recently-thriving-herring/
[4] Brent B. Hughes, *et al.*, The Nature Conservancy & Pacific Marine & Estuarine Fish Habitat Partnership, *Nursery Functions of U.S. West Coast Estuaries: The State of Knowledge for Juveniles of Focal Invertebrate and Fish Species*, 2014, page 124.
[5] *Id.* at page 125.

Need for More Research and Monitoring of Tomales Bay's Herring Populations

More monitoring and data collection are needed before the commercial Herring fishery can be re-opened in Tomales Bay. The Herring biomass research for Tomales Bay is extremely outdated. The biomass research studies for Tomales Bay cited in the Herring FMP are from the 1970s to early 1990s. A 2015 study from the Pacific Marine & Estuarine Fish Habitat Partnership and National Fish Habitat Partnership found that "…forage fish, such as Pacific herring, should be among the focal species monitored for understanding stressors and restoration potential."[6] Biomass research unique to Tomales Bay is important, as many researchers believe the San Francisco Bay and Tomales Bay Herring populations are distinct.

***§ 28.60. Pacific Herring Eggs*: No Recreational Take of Roe in Tomales Bay**

As a supplemental comment, we recommend that recreational take of Herring eggs or roe be prohibited in Tomales Bay. This would require further revision to California Code of Regulations (CCR) Section 28.60, *Pacific Herring Eggs*, or another section of the CCR. Section 28.60, as proposed includes a limit of "Twenty-five pounds (including plants) wet weight of Pacific Herring eggs…per day for recreational purposes." This limit is not sustainable for Tomales Bay's sensitive waterbird and eelgrass habitats[7]. Many of the Tomales Bay waterbird populations have experienced significant declines and have special status designations. According to Audubon Canyon Ranch (ACR), "[o]n Tomales Bay, where ACR has monitored shorebirds since 1989, mean winter shorebird numbers have declined from about 20,000 individual birds in the late 1980s to about 6,000-7,000 individual birds currently, a population decline of roughly 65%...."[8]

Tomales Bay also serves as important eelgrass[9] and marine mammal habitat. The vast majority of Herring roe are deposited on eelgrass in Tomales Bay. Anna L. Suer states in her book, *The Herring of San Francisco and Tomales Bays*, that eelgrass is the predominant vegetation upon which Herring eggs are found in Tomales Bay.[10] The Nature Conservancy's 2018 study states that, "Pacific herring spawning is associated with eelgrass meadows in U.S. West Coast estuaries, including multiple areas of…Tomales, and San Francisco bays."[11]

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[6] Jason T. Toft, *et al.*, Pacific Marine & Estuarine Fish Habitat Partnership & National Fish Habitat Partnership, *Nursery Functions of West Coast Estuaries: Data Assessment for Juveniles of 15 Focal Fish and Crustacean Species*, November 2015, page 44, *available at*: http://www.pacificfishhabitat.org/wp-content/uploads/2017/09/pmep_assessment-report.pdf
[7] Tomales Bay is listed as a Ramsar Wetland of International Importance.
[8] Audubon Canyon Ranch, *A local look at the sweeping decline in North American birds*, September 20, 2019, *available at*: https://www.egret.org/local-look-sweeping-decline-north-american-birds
[9] *See Pacific Herring FMP*, eelgrass map, page 328; page 2-26; & Merkel and Associates, 2017. Tomales Bay Eelgrass Inventory. Report nr M&A #05-024-38.
[10] Anna L. Suer, *The Herring of San Francisco and Tomales Bays*, 1987, page 10.
[11] Kate Sherman & Lisa A. DeBruyckere, The Nature Conservancy & PMEP, *Eelgrass Habitats on the U.S. West Coast: State of the Knowledge of Eelgrass Ecosystem Services and Eelgrass Extent*, 2018, page 40, *available at*: http://www.pacificfishhabitat.org/wp-content/uploads/2017/09/EelGrass_Report_Final_ForPrint_web.pdf

Even though the state regulations currently prohibit harm to eelgrass[12], we are concerned that recreational fisher people may not be able to distinguish between other types of vegetation and eelgrass. Also, there is limited enforcement. For these reasons, we recommend a closure (or zero limit) of recreational roe take in Tomales Bay.

In closing, we thank the Fish and Game Commission, the Department, and all of the stakeholders involved in the valuable process of developing the Herring FMP and the implementing regulations.

Respectfully,

Morgan Patton
Executive Director

Ashley Eagle-Gibbs
Conservation Director

cc: Tom Greiner, Environmental Scientist, California Department of Fish and Wildlife
Andrew Weltz, Environmental Scientist, California Department of Fish and Wildlife

[12] 2019-20, *California Ocean Sportfishing Regulations*, Section 30.10, page 51, *available at*: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165608&inline

State of California
Department of Fish and Wildlife

Received May 24, 2019
Original signed copy on file.

M e m o r a n d u m

Date: May 23, 2019

To: Melissa Miller-Henson
Acting Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Agenda item for June 13, 2019, Fish and Game Commission Meeting Re: Request for Notice Authorization Re: California Pacific Herring Fishery Management Plan and Implementing Regulations**

The Department of Fish and Wildlife (Department) requests the Fish and Game Commission (Commission) authorize publication of notice of its intent to consider amendments to existing regulations in Title 14, California Code of Regulations (CCR) concerning commercial and recreational Pacific Herring (Herring), for alignment with the California Pacific Herring Fishery Management Plan (Herring FMP). The attached Initial Statement of Reasons for Regulatory Action is provided in support of establishing the proposed implementing regulations. The proposed implementing regulations will cover the following major areas:

1) Amendments to existing recreational Herring fishery regulations in Sections 27.60, 28.60 and 28.62:

   - will establish a maximum recreational take limit (bag) for Pacific herring.
   - The Fish and Game Commission is asked to select a bag limit within the range of <u>zero to ten (0-10) gallons</u>, according to the Herring Fishery Management Plan.
   - The Department's recommendation is five (5) gallons, equivalent to about 260 fish or 50 pounds.

2) A new Article in Chapter 6.0, Subdivision 1, Division 1, Title 14, CCR and new Sections 55.00, 55.01, and 55.02 will be established. The proposed new sections will:

   - describe the purpose and scope of the Herring FMP;
   - provide relevant definitions used in the Herring FMP; and
   - describe management processes and strategy.

3) Commercial Herring fishery regulatory amendments are proposed to Sections 163, 163.1, 163.5, and 164, as well as amendments to Section 705, adopting forms and fees consistent with the new Herring regulations. The purpose of the regulations is to:

   - implement the Herring FMP, produced pursuant to the Marine Life Management Act;
   - improve management of the existing commercial fisheries; and
   - support the sustainable and orderly use of this natural resource.

The Draft Herring Fishery Management Plan fulfills the Commission's obligation to comply with the California Environmental Quality Act (CEQA) [Public Resources Code (PRC) §21000 et seq.] in considering and adopting an FMP and associated implementing regulations.

Authorization of this request to publish notice will allow for discussion and possible adoption at the August 7-8, 2019 and October 9-10, 2019 meetings, respectively. The Department requests an effective date of March 1, 2020 for these regulations.

If you have any questions or need additional information, please contact Dr. Craig Shuman, Marine Regional Manager at (916) 445-6459. The public notice for this rulemaking should identify Environmental Scientist, Andrew Weltz, as the Department's point of contact for this rulemaking. His contact information is (707) 576-2896 or Andrew.Weltz@wildlife.ca.gov.

Attachments

ec: Stafford Lehr, Deputy Director
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STATE OF CALIFORNIA
FISH AND GAME COMMISSION
INITIAL STATEMENT OF REASONS FOR REGULATORY ACTION
Amend Sections 27.60 and 28.60;
Add Section 28.62; Add Article 6, Sections 55,00, 55.01 and 55.02;
Amend Sections 163, 163.1, 163.5, 164, and 705;

Title 14, California Code of Regulations.
Re: California Pacific Herring Fishery Management Plan Implementing Regulations

I. Date of Initial Statement of Reasons: May 15, 2019

II. Dates and Locations of Scheduled Hearings

(a) Notice Hearing: Date: June 13, 2019
Location: Redding, CA

(b) Discussion Hearing: Date: August 8, 2019
Location: Sacramento, CA

(c) Adoption Hearing: Date: October 10, 2019
Location: San Diego, CA

III. Description of Regulatory Action

(a) Statement of Specific Purpose of Regulation Change and Factual Basis for Determining that Regulation Change is Reasonably Necessary:

The purpose of these proposed amendments to regulations is the implementation of the 2019 California Pacific Herring Fishery Management Plan (Herring FMP). This Fishery Management Plan (FMP) has been produced pursuant to the Marine Life Management Act (MLMA). The amendments are further necessary to improve management of the existing commercial and recreational Pacific Herring (herring) (*Clupea pallasii*) fisheries and to support the sustainable and orderly use of this natural resource.

The MLMA of 1999, as set forth in Fish and Game Code [Division 6. Fish, Part 1.7 Conservation and Management of Marine Living Resources, sections 90-99.5, 7050-7090, 8585-8589.7], affirms the State's policy of ensuring "the conservation, sustainable use, and, where feasible, restoration of California's marine living resources for the benefit of all the citizens of the State" (FGC Section 7050(b)). In this instance that resource is the California Pacific Herring. The Department of Fish and Wildlife (Department) is responsible for the development of the Herring FMP, and implementation of regulations promulgated by the Fish and Game Commission (Commission). The process of developing FMPs and the implementing regulations is expected to make management objectives and marine fishery regulations more readily available and clearer to the Commission, the Department, and the public. The Herring FMP (attachment 1) will be presented to the Commission in June 2019 and is scheduled for adoption at the Commission's October 2019 meeting.

An extensive public scoping process was conducted by the Department to inform the development of the Herring FMP and the proposed implementing regulations. In accordance with the MLMA (FGC Section 7076(a)), the Department sought input from individuals representing a broad range of stakeholder interests to provide advice and assistance in developing the Herring FMP through a series of scoping meetings. A Herring FMP Steering Committee (SC) was formed in the spring of 2016 to provide guidance on objectives as well as develop management recommendations for the Herring FMP. Consisting of commercial herring fleet leaders, representatives from conservation non-governmental organizations (NGOs) and Department staff, the SC evolved out of an informal discussion group that had been meeting since 2012 to discuss the management needs of the herring fishery. The SC provided guidance throughout the Herring FMP process and communicated the goals and strategies of the plan to their wider communities. In 2016, the Department presented the scope of the Herring FMP development process to the Commission and solicited feedback through the public process. In addition, the Department requested feedback from California Native American Tribes on the scope of the Herring FMP and engaged all herring permit holders on the desire and need for regulatory change through a survey. The feedback and results of the survey were used to develop the regulatory proposal. The Herring FMP has benefited from additional input from stakeholders through presentations to the Commission and in other public meetings (both web-based and in-person) (see Part (f), Public Discussions of Proposed Regulations Prior to Notice Publication).

To understand the need for regulatory changes and the potential impacts of those changes, the Herring FMP Project Management Consultant Team talked with past and present Department staff, as well as industry representatives and conservation groups. Using this information, the SC reached consensus on several regulatory amendments to standardize and clarify the regulatory language across sectors and areas, and to make the regulations consistent with those used in other fisheries in California. Proposed regulations for the commercial gill net and herring eggs on kelp (HEOK) sectors, as well as the recreational fishery, are more streamlined and reflective of current conditions.

Once adopted and implemented through the proposed regulations, the Herring FMP will establish a management strategy for the herring recreational and commercial fisheries and detail the procedures by which the Department manages, and the Commission regulates, the herring resource. As the price of herring and participation in the herring fishery has declined over recent decades, many management methods (a platoon system used to divide gill net vessels into groups, the substitution of fishery permits, and the conversion of permits between gear types) have either become outdated or no longer necessary. Chapter 7 of the Herring FMP provides a comprehensive and adaptive management strategy that reflects the current fleet size, is responsive to environmental and socioeconomic changes, and establishes a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem. The Herring FMP prescribes procedures to: monitor herring populations in the four management areas (San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor); analyze the data collected via the monitoring protocol to estimate Spawning Stock Biomass (SSB); develop quotas based on current SSB using a Harvest Control Rule (HCR) for the San Francisco Bay commercial fishery (attachment 1; Section 7.7); track indicators to monitor ecosystem conditions and adjust quotas in San Francisco Bay as needed; and set precautionary quotas in the northern management areas (Tomales Bay, Humboldt Bay and Crescent City Harbor).

The current regulations for the commercial herring fishery are found in sections 163, 163.1, 163.5 and 164. Section 163 currently describes permits to take herring, methods of take allowed in the gill net fishery, landing requirements, and requirements for the Herring Buyer's Permit. Section 163.1 describes the conditions for permit transfers. Section 163.5 details penalties for violations in the herring fishery in lieu of suspension and revocation of permits. Section 164 describes the methods of take and landing requirements in the HEOK fishery. Recreational regulations governing the take of HEOK are found in Section 28.60. There are currently no recreational regulations in Section 28.62 on the take of herring, as this language has been repealed.

Upon the adoption of the Herring FMP by the Commission, a corresponding set of implementing regulations must be adopted to enact the Herring FMP. Given the scale of changes to the herring permitting system, the Department recommends deleting all of the existing language in sections 163, 163.1, 163.5, and 164 and drafting new regulatory language in these sections. The new language in 163 will define herring fishing permits (both herring and HEOK), including permit transfers and revocation conditions, making the current language in 163.1 (Herring Permit Transfers) and 163.5 (Penalties in Lieu of Suspension and Revocation) obsolete. The proposed language in Section 163.1 will describe methods of take for herring, the proposed language in Section 163.5 will describe the conditions of the Herring Buyer's Permits, and the proposed language in Section 164 will describe the methods of take for HEOK. In addition, a bag limit for recreational take of herring will be instituted in Section 28.62. General Fishery Management Plan regulations will be found in Chapter 5.5 Article 1, Section 50 et seq.

Additionally, the Fish and Game Code provides authority for the Commission to adopt regulations that implement a fishery management plan or plan amendment and make inoperative any fishery management statute that applies to that fishery.

- 7071 (b) In the case of any fishery for which the Commission has management authority, ... regulations that the Commission adopts to implement a fishery management plan or plan amendment for that fishery may make inoperative, in regard to that fishery, any fishery management statute that applies to that fishery.

- 7078 (f) Regulations ... shall specify any statute ... that is to become inoperative ... The list shall designate each statute or regulation by individual section number, rather than by reference to articles or chapters.

To implement the conservation and management measurements identified in the Herring FMP, the proposed regulations will render the following sections of the Fish Game Code inoperative once adopted:

INOPERATIVE FISH AND GAME CODE SECTION	DESCRIPTION OF STATUTE	SUPERCEDED BY PROPOSED REGULATION SUBSECTION	FISHERY MANAGEMENT PLAN CHAPTER SECTIONS
8389	Herring Eggs; Authority to prescribe regs, permits, royalty fee, and limits, incidental take HEOK	55.02(a), (d), and (e); 163(b) and (c); 164(a) and (b); 705(a).	7.8, 7.9, 9.1
8550	Fish and Game Commission regulates herring, number of permits, amount of take per permit	55.02(a), (d), and (e).	4.7, 7.7, 7.8, 7.9, 9.1
8550.5	Herring net permit fee	163(a) and (b), 705(a).	7.8, 9.1
8552	Herring Roe permit conditions	163(a), (b), and (h).	4.7, 7.8, 7.9, 9.1
8552.2	Herring permit transferability - experience points	163(b), (h)	7.8, 9.1
8552.3	Fish and Game Commission regulate permit transfers	55.02(e); 163(b), (c), and (h)	7.8, 9.1
8552.4	Department to hold drawing for revoked permits - experience points	163(b) and (d)	4.7, 7.8, 9.1
8552.5	Fish and Game Commission may revoke herring permits	55.02(e), 163(g)	7.8, 9.1
8552.6	Herring permit ownership	163(c), (h), and (e)	7.8, 9.1
8552.7	Transfer fee is $5000	705(b)	7.8, 9.1
8552.8	Experience points – permit sales and transfers	163(d) and (h)	7.8, 9.1
8553	Fish and Game Commission regulates herring	55.02(d), 55.02(e)	7.9, 9.1
8554	Fish and Game Commission may regulate temporary substitution of permittee	163(e)	7.8, 9.1

INOPERATIVE FISH AND GAME CODE SECTION	DESCRIPTION OF STATUTE	SUPERCEDED BY PROPOSED REGULATION SUBSECTION	FISHERY MANAGEMENT PLAN CHAPTER SECTIONS
8556	Fish and Game Commission regulates take by gill net and mesh size.	55.02(e), 163.1(c)	7.8, 9.1
8557	Fish and Game Commission regulates herring take by round net	55.02(b), 163.1(c)	5.4, 7.8, 9.1
8558	Herring Research Account	163(b), (c), and (d), 705(a)	5.3, 7.8, 9.1
8558.1	Herring Stamp and Fee	163(b), (c), and (d), 705(a)	5.3, 7.8, 9.1
8558.2	Difference between Res and Non-res fees to be deposited in Research Account	163(b), (c), and (d), 705(a)	5.3, 7.8, 9.1
8558.3	1/2 of herring roe fees goes to research	163(b), (c), and (d); 705(a)	7.8, 9.1
8559	FGC shall set experience requirements	163(c), (d), and (h); 705(a)	4.7, 7.8, 9.1

The proposed regulations are drafted to serve the sustainability and social policy objectives enumerated in FGC Sections 7050, 7055, and 7056.

PROPOSED REGULATORY CHANGES FOR RECREATIONAL HERRING FISHING

- **Amend Section 27.60. Limit.**

Proposed Changes
In subsection 27.60(b) Pacific herring is included in the list of species with no limits on recreational catch. The proposed regulations in Section 28.62 will set a limit for recreational take of Pacific herring.

Necessity and Rationale
As part of the Herring FMP, Section 28.62 will be amended to establish a recreational bag limit for Pacific herring. As a result, it is necessary to delete “Pacific herring” from Section 27.60 so that it does not conflict with this change.

- **Amend 28.60. Herring Eggs.**

Proposed Changes
Currently, the title of Section 28.60 reads “Herring Eggs”. Including the word “Pacific” in the title correctly refers to Pacific Herring (*Clupea pallasii*). Additional text clarifies that the regulation establishes a daily limit for recreational take of Pacific Herring eggs.

Necessity and Rationale:
This is a non-substantive change to indicate the correct species of herring to which the regulation applies, and to clarify that the regulation establishes a daily limit on recreational take of Pacific Herring eggs.

- **Add Section 28.62. Pacific Herring Bag Limit.**

[Note: the original Section 28.62 was repealed in 1988. In order to use this section number in the present rulemaking, the remaining text (the note section and title affirming the repeal) in Title 14 is deleted in its entirety.]

Proposed Change
Add a new bag limit for recreational take of herring. The proposed regulation sets a recreational daily bag limit in the range of zero to ten (0-10) gallons. The FMP recommends a range between 0 and 100 lb. (45-kg) as a daily bag limit. Ten gallons is equivalent to two 5-gallon buckets of herring, each containing approximately 260 fish.

At the October 10, 2019 meeting, the Commission will make a decision regarding the recreational daily bag limit. This regulation is expected to clarify and reduce the illegal commercialization of recreational take.

Necessity and Rationale
There are currently no regulations governing the recreational take of herring. Reports from Law Enforcement Division personnel indicate that an increase in the observed catch by some participants may be attributable to commercialization of the recreational fishery. The Herring FMP therefore proposes that the recreational fishery be managed using a bag limit.

The Department recommends a bag limit of five gallons, which is equivalent to 50 pounds of herring, or approximately 260 fish. Based on input from stakeholders, this is considered to be an adequate amount to provide a fulfilling recreational experience for participants. This limit is designed to be clear and easily enforceable. Fish and Wildlife Officers suggested measuring catch by using a 5-gallon bucket, which is a common method of holding fish and easy to enforce.

IMPLEMENTING THE 2019 CALIFORNIA PACIFIC HERRING FISHERY MANAGEMENT PLAN

- **Add Article 6. California Pacific Herring Fishery Management Plan to Title 14, CCR:**

This regulatory proposal will add Article 6 California Pacific Herring Fishery Management Plan, specifically including the new sections 55.00, 55.01, and 55.02. Chapter 5.5, Title 14, CCR, sets forth the implementing regulations and management strategies of each of the state’s adopted FMPs. Each Article generally describes the 1) Purpose and Scope of each FMP, 2) relevant Definitions used in each FMP, and 3) Management Process and Strategy setting forth the process and timing of management framework (e.g., harvest control rules, allocations).

- **Add Section 55.00. Purpose and Scope.**

This section clarifies the purpose of this article consistent with the objectives and goals of the MLMA. It also states that this article together with other applicable state and federal laws and regulations will govern the herring fisheries. Finally, this section includes a list of the Fish and Game Code sections that are being made inoperative by the new Herring FMP. Pursuant to Fish and Game Code Section 7071(b) regulations adopted by the Commission to implement a FMP may make inoperative any fishery management statute that applies to that fishery.

- **Add Section 55.01. Definitions.**

This section provides definitions that are specific to this new article. All definitions in this section are based on and are consistent with the definitions found in the Herring FMP. The definitions are also consistent with other provisions of state and federal laws. Definitions are provided to assure uniform understanding of the provisions.

- **Add Section 55.02. Management Strategy.**

The Management Strategy will conform to the goals, objectives, criteria, procedures and guidelines set forth in Chapter 7 of the Herring FMP. The Herring FMP is "Incorporated by Reference" and has the effect of regulation in Title 14, CCR. The Herring FMP is a large document that would be unduly cumbersome and impractical to print in its entirety in Title 14. Additionally, it is easily accessible from the Department's website.

The Management Strategy in Chapter 7 consists of procedures to: 1) monitor herring populations and set quotas in the four management areas (San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor), 2) analyze the data collected via the monitoring protocol to estimate SSB in San Francisco Bay, 3) develop quotas based on current SSB using a HCR in San Francisco Bay, 4) track indicators to monitor ecosystem conditions, and 5) establish additional management measures to regulate fishing.

The Herring FMP prescribes a three-tiered management approach to prioritize monitoring efforts and apply appropriate levels of management to fit the fishery activity level. Using this approach, each management area falls into one of three tiers based on the level of fishing occurring and the amount of information available on the herring population in that area. The level of monitoring effort is dictated by the size and value of the fishery. Quotas are determined based on the information available. When very little information is available, quotas are set in a more precautionary manner to minimize the risk to the stock. Conversely, as greater monitoring occurs higher harvest rates may be appropriate if stock size can support higher levels of catch. Currently, Tomales Bay, Humboldt Bay, and Crescent City Harbor are Tier 1 fisheries, and the San Francisco Bay management area is the only herring fishery in California that currently requires a Tier 3 protocol.

- Tier 1 herring management areas are those areas where low, precautionary quotas are available, but no fishing has occurred in the prior season. If or when any herring permits are fished in a Tier 1 management area, that area will be managed under a Tier 2 management strategy during the subsequent season.

- Tier 2 management includes collection of fishery-dependent data and the potential for collection of additional fishery-independent data via the rapid spawn assessment method, as described in Appendix P of the Herring FMP. A minimal level of quota adjustment may occur under Tier 2 management if the Department estimates SSB for that area. A Tier 2 management area moves to Tier 3 when the Department determines that the size of the fishery, in terms of potential catch or the number of participants, warrants more intensive monitoring. This may occur due to increases in the ex-vessel price of herring, leading to increased utilization of existing permits and requests for new permits.

- Tier 3 requires a more comprehensive management protocol to ensure sustainable harvest and would also require additional staff and resources from the Department. Quotas in Tier 3 management areas are set using an HCR, which is a predetermined rule for determining an appropriate catch limit based on the current SSB estimate. Also, the status of additional environmental and ecosystem indicators, as set forth in the FMP (attachment 1; Section 7.7.2) will be examined in order to monitor current ecosystem conditions and adjust quotas as needed to reduce the ecosystem impacts of fishing, and the Department will include information on these indicators in the Pacific Herring Enhanced Status Report.

  A Tier 3 management area may also be assigned to a lower tier should effort change or an active fishery move into a non-active mode.

Necessity and Rationale

The MLMA directs the Department to ensure the sustainable use of the state's living marine resources (Fish and Game Code § 7050(b)). The MLMA identifies FMPs as the primary tool for achieving this goal (Fish and Game Code § 7072). Each FMP shall specify criteria for identifying when a fishery is overfished (Fish and Game Code § 7086(a)) and provide measures to prevent, end, or otherwise address overfishing. Should a fishery become overfished, FMPs provide the Department with the necessary steps to rebuild the fishery in a timely manner not to exceed ten years except in cases where the biology of the fish population or other environmental conditions dictate otherwise. Every recreational and commercial marine fishery shall be managed so that the long-term health of the resource is not sacrificed for short-term benefits.

Beyond aligning with the MLMA, a primary goal of the Herring FMP was to develop and test an HCR for the commercial herring fishery in San Francisco Bay – the most productive and actively fished management area. More than 90% of California's herring landings have come from San Francisco Bay, and it is the only bay where fishing has occurred since 2007. Although the herring fishery in San Francisco Bay has been managed using a quota since its inception in 1972, there has never been a formal rule for setting that quota. An HCR, which is a set of pre-agreed rules for determining a management action in response to changes in indicators of stock status with respect to reference points, is a key component of many effective harvest strategies. A clearly defined HCR increases transparency by providing a pre-determined and structured approach for making annual management decisions based on current stock status, as well as ensures that those decisions are in line with long-term management objectives. While herring fishery management in California has been precautionary in recent years, the proposed HCR provides the necessary tool to transition the ad hoc annual quota-setting process to a more stable, less costly, and more efficient management system. The HCR was developed to: 1) allow for transparency in decision-making, 2) account for ecosystem considerations, 3) reflect current precautionary management, and 4) streamline the rule-making process each year.

The herring fishery has been managed by the Commission and the Department through an annual rulemaking process under the Administrative Procedures Act (APA) that includes California Environmental Quality Act (CEQA) compliance. Changing quotas on a yearly basis has required both a rulemaking package to change Title 14 of the CCR, as well as the associated documentation required under CEQA. The work associated with this regulatory process has made it arduous to change the quota each year and constitutes a barrier to a responsive management system. The proposed HCR improves this process by creating a predetermined decision-making framework reflective of management objectives and best available science, and the implementing regulations will establish the authority of the Director of the Department to alter quotas under the framework established in the Herring FMP. Transferring authority to the Department Director from the Commission, with a clear regulatory framework to limit the Director's discretion and guide decision making, increases efficiency and allows for more adaptive management when critical decisions need to be made. While authority to set the quota is transferred to the Director of the Department, the proposed management strategy maintains the authority of the Commission to establish additional management measures to further regulate fishing in all management areas.

AMENDMENTS TO THE REGULATION OF THE PACIFIC HERRING COMMERCIAL FISHERY

- **Delete the Existing Regulations (including subsections a-j) in Section 163 Title 14, CCR, Harvest of Herring; and replace with Pacific Herring Permits**

Proposed Changes
The current regulations describe the requirements to obtain a permit to commercially take herring in San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor, as well as the allowed methods of take for herring. These regulations will be replaced with new sections (a-i) that clearly describes the classes of permits, application requirements, and renewal and permit transfer procedures.

Necessity and Rationale
The current regulations in Section 163 were initially designed more than 40 years ago, when the modern herring fishery in California began. Since that time, these regulations have been amended more than 30 times in an *ad hoc* fashion as the fishery evolved and issues arose. Now, the Herring FMP will guide management of the fishery, and updated regulations are needed to fully implement that FMP.

- **Section 163. Pacific Herring Permits.**

The new regulations, described in detail by subsection below, will conform the herring commercial fishery to the Herring FMP, anticipated to be adopted by the Commission on October 10, 2019.

- **Add Subsection 163(a) Permit Required.**

Proposed Changes
Herring and herring eggs on kelp (HEOK) may be taken for commercial purposes only under a revocable permit issued by the Department.

Necessity and Rationale
Under Fish and Game Code Section 8140, the take of fish for commercial purposes is allowed at any time unless otherwise restricted pursuant to state law or regulations. This regulation is needed to make clear a herring permit is required, in order to fully implement the Herring FMP.

o **Add Subsection 163(b) Classes of Permits.**

Proposed Changes

The proposed language in subsection 163(b) eliminates the four permit classes (converted round haul, also known as “CH”; Odd; Even; and December, also known as “DH”, permits) associated with the platoon system in San Francisco Bay, and describes the process for conversion to a permit called the San Francisco Bay Herring Permit. To facilitate this conversion, all existing Odd, Even, and December permits will be automatically converted to Temporary permits on April 1, 2020. Temporary permits allow permittees to fish one full net (65 fathoms) and are transferrable and renewable through March 31, 2025. Permittees who would like to participate in the fishery beyond the 2024-2025 season must obtain a second Temporary permit from a willing seller. If a single permittee holds two Temporary permits they will be automatically and permanently converted to a San Francisco Bay herring permit. Subject to the terms and conditions in the proposed subsections 163 (b), (c) and (h), San Francisco Bay herring permits allow the holder to fish two gill nets at one time (the maximum amount that can be fished from one vessel) and are renewable and transferrable. All existing CH permits will be automatically converted to San Francisco Bay herring permits on April 1, 2020.

The proposed regulations retain the three permit classes in the other herring fishing areas, namely Tomales Bay herring permits, Humboldt Bay herring permits, and Crescent City herring permits. Prior to the adoption of the Herring FMP, HEOK participants were gill net permit holders that elected to fish HEOK instead of gill net. Under the adopted Herring FMP, the HEOK permit will be a separate permit. Existing HEOK participants will be granted a HEOK permit and have one year (until March 31, 2021) to elect to convert it to a Temporary permit. As with permits for herring, HEOK permits are renewable and transferrable subject to the terms and conditions in the proposed subsections 163(c) and (h).

The proposed regulations eliminate partnership herring permits and requires partnerships to designate, by March 15, 2020, a partner to receive the permit.

Necessity and Rationale

The Herring FMP Project Management Consultant Team talked with past and present Department biologists and managers, Law Enforcement staff, and the License and Revenue Branch, as well as industry representatives and conservation groups to understand the need for regulatory changes and the potential impacts of those changes. The changes identified reflect the current nature of both the gill net and HEOK fisheries, standardize and clarify regulatory language, and ensure the regulations are consistent with those used in other fisheries in California.

Gill Net Permits in San Francisco Bay

During the 1993-1994 season, the Commission made a major change to the permit system which was aimed at reducing the number of vessels in the San Francisco Bay fleet. This change reduced the amount of gear that could be fished by an individual gill net permit from 130 fathoms of net (2 shackles) to 65 fathoms (1 shackle) – effectively limiting each permit to a single net and cutting the amount of gear used in half. This change, coupled with the platoon system, allows each December, Even, and Odd permit holder to fish one full net (65 fathoms) every other week of the season. Given that permit holders are only allowed to hold up to three permits and vessels require four permits on board to fish two full nets during every week of the season, permittees have had to partner up on vessels in order to fish a full complement of gear (two 65 fathom gill nets). To allow this, another regulation change was required to allow two different permittees' permits to be fished on the same boat simultaneously.

The platoon system and permit restrictions were created to manage a much larger herring fleet than the current one. Restriction on the number of permits date back to the 1980s and 1990s when participation was high, and the platoon system was originally developed to reduce crowding on the fishing grounds while trying to maintain access for the greatest possible number of fishermen. However, since these regulations were established, a decrease in the price of herring has reduced the number of permits held in San Francisco Bay to the lowest number since the fishery began. A survey on the proposed regulatory changes was mailed to all 139 commercial permit holders and 36% of permittees responded. Based on the responses, there is broad support to eliminate the platoon system (73%). The proposed regulations to convert all existing platoon permits to San Francisco Bay herring permits within five years will eliminate the need for permittees to partner up on a single vessel to fish a full complement of gear. The proposed regulation eliminates the outdated and overly complex platoon system. It also reduces the current disproportionate administrative burden associated with the fishery, simplifies enforcement, and provides a path for a capacity reduction (see proposed addition of subsection 163(d), et seq. Applications for New Permits).

The proposed regulations eliminate partnerships to standardize the permitting structure, allowing permits to be issued to individuals, consistent with other permit programs. The proposed language establishes March15, 2020, as the deadline for partnerships to designate an individual to receive the permit. This deadline would allow the Department two weeks to facilitate the conversion of permits on April 1, 2020.

Permits in Other Areas
There are no changes to the permit classes for the other areas (Tomales Bay, Humboldt Bay, and Crescent City Harbor).

HEOK Permits
Originally, HEOK fishermen held permits in the herring sector (either as gill netters or seiners) and elected to transfer their permit to the HEOK fishery. A number of prior regulatory changes were therefore designed to maintain parity between the gill net and HEOK sectors. This has led to additional complication in the regulations. The Herring FMP recognizes that the HEOK and gill net fishery sectors are very different, and thus the proposed changes restructure the regulations so that HEOK permits are a separate permit class. Separating the HEOK permit streamlines and clarifies regulations, as many of the proposed changes for the gill net fishery do not apply to the HEOK sector. In developing the proposed permit system for the HEOK sector, the Herring FMP Project Management Consultant Team worked extensively with industry representatives and long-time fishermen to address any concerns while still making the permitting process clear and enforceable

o **Add Subsection 163(c) Permit Renewal.**

Proposed Changes
The current regulations specify the qualifying criteria and procedures for the renewal of herring permits across multiple subsections in 163, 163.1, and 164. The proposed language in subsection 163(c) now combines these renewal requirements and procedures for all permit classes. Current regulations specify that permits are to be renewed annually and are only valid for the following season. The proposed language in subsection 163(c)(1) retains that restriction. The proposed regulations also provide non-substantive updates to the language describing that late fees, deadlines, and renewal appeal conditions. Additionally, more specificity on the appeal process is added. The primary changes to the regulations governing permit renewals include:

Eligibility Requirements
Current regulations specify the eligibility requirements for renewing a permit, which include holding a commercial fishing license, being a permittee during the previous herring season, qualifying for an Odd, Even, or DH permit, and having submitted all forms and payment associated with quota overage in the prior year. The proposed regulation removes the language specifying Odd, Even, and December platoons and streamlines the language. The proposed language in 163(c)(2) specifies that applicants may renew a permit provided they meet the following qualifications:

- They hold a current California commercial fishing license;
- Had a valid, unrevoked herring permit in the preceding permit year; and
- Have submitted Release of Property Form FG-MR-674 and payments associated with any quota overages from the prior year. (Note: FG-MR -674 (Rev. 5/13) was deleted with the current text of 163 and is Incorporated by Reference in the proposed text 163(c), without change.)

Type of Permit Renewed
Current regulations specify that upon renewal, current permit holders will be issued a permit for the same area and gear type that they had previously. The proposed language in subsection 163(c)(3) includes a change indicating that applicants will be issued a permit of the same class (as specified in proposed subsection 163(b)) they held in the previous year with the exception of those permittees who hold two Temporary permits. Two Temporary permits will be automatically converted to one San Francisco Bay herring permit.

Number of Permits Allowed
Current regulations in Section 163.1 specify that permit holders in San Francisco Bay may hold no more than one permit in each platoon in San Francisco Bay, and no more than three permits total. The proposed language in subsection 163(c)(4) states that permittees are allowed to hold a maximum of one San Francisco Bay, Tomales Bay, Humboldt Bay, or Crescent City herring permit, and a maximum of one HEOK permit. With the elimination of the platoon structure, the separation of the HEOK permit, and the standardization of the amount of gear allowed under a permit, this reduction in the maximum number of permits permittees are allowed to hold does not result in a loss of fishing rights.

Herring Permit Renewals
Subsection 163(c)(5) retains the requirement that permittees must designate a vessel to fish their permit on when renewing permits, as well as the process for changing vessel designations mid-season. Additional language explains that up to two Temporary permits or one permit of any other class may be assigned to a vessel.

HEOK Permit Renewals
Current regulations specify that the Department must be notified of any vessels assisting with HEOK fishing, and the procedure for notification. The proposed language in subsection 163(c)(6) retains this requirement. As with the current regulations, HEOK permittees may designate up to two other individuals with commercial fishing licenses to act as Authorized Agents for the permittee. The proposed language retains this as well as the description of what an Authorized Agent may do. The proposed changes allow Authorized Agents to serve on up to two permits and identify submission of the Herring-Eggs-on-Kelp Permit Application as the mechanism for replacing an Authorized Agent mid-season.

Renewal Deadline
Proposed subsection 163(c)(7) changes the annual deadline for renewals from the first Friday in October to May 31, 2020. Applications for renewal of herring permits must be received by the department or, if mailed, postmarked no later than May 31, 2020. Beginning in 2021, applications for renewal must be received by the Department, or if mailed, postmarked no later than April 30 of each year. It also removes language stating that permits to take herring for commercial purposes will be issued by the Department beginning November 15. In the proposed regulations, permits will be issued as renewal applications are received. The requirement that permits be sent by first class mail is removed.

Late Fees and Appeals Process
Non-substantive changes (same as existing requirement), including reorganization of existing regulations. Additionally, more specificity on the appeal process is added.

Necessity and Rationale
Annual Renewal
Annual renewal requirements from current regulation are maintained in proposed regulatory language, pursuant to Fish and Game Code Section 7858.

Eligibility Requirements
Eligibility requirements from existing regulations are maintained in proposed regulatory language. Platoons are proposed to be eliminated so references to platoons are removed, and the language is streamlined.

Type of Permit Renewed
The proposed references to permit class streamline the language and is consistent with the new language in subsection 163(b) describing the different permit classes. Converting two Temporary permits to one San Francisco Bay herring permit is necessary to facilitate the transition from the existing platoon system to the new permit system in which a single permit allows the holder to fish a full complement of fishing gear without needing to partner with another permittee.

Number of Permits Allowed
Eliminating the platoon system and permit conversion process means herring permittees will no longer need to own multiple permits to fish a full complement of gear. It is also important for the opportunity to fish herring be extended to as many participants as possible while still ensuring the biological and economic sustainability of the fishery. The regulations therefore propose that no single permittee be able to hold more than one permit to take herring, not including Temporary permits. HEOK permittees are allowed to hold up to one permit. Historically there has been much less demand for entry into the HEOK fishery, so there is less concern about limiting capacity in what is already a small, niche fishery.

Herring Permit Renewals
The current regulations require permits to be assigned to a vessel in order to be fished. Under the proposed language, up to two Temporary permits can be assigned to a single vessel to allow permittees to continue to work together to fish a full complement of gear during the five year transition period, while only one permit of the other herring permit classes can be assigned to a vessel. The rest of the proposed language largely streamlines the description of the administrative processes associated with designating or changing a vessel. This section also outlines an appeal process for anyone denied a change in vessel designation. The appeal and supporting information is submitted to the Commission in writing, along with a process to allow

for the Department to respond to the appeal. Providing the information in writing helps clarify what issues are in play and can expedite the appeal process. A similar procedure is used in other Department permitting contexts. The 60-day timeline provides adequate time for a permittee to submit an appeal while still putting a limit on how long after denial an appeal can be submitted. The Department's 60-day response period similarly provides an adequate timeline for response while ensuring the next steps in the appeal process occur quickly.

HEOK Permit Renewals
The HEOK fishery sector, in which harvested kelp is strung from rafts or lines and positioned to induce herring to spawn on the kelp, is unique. Under current regulations, a very large spawn (more than an individual's quota) could occur on a single set of gear. Given that a permittee could only serve as an Authorized Agent on a single permit, once the individual quota was reached on both permits, the remaining eggs on kelp could not be retained and had to be returned to the water. Allowing HEOK permittees to serve as an Authorized Agent on up to two permits facilitates collaboration between permittees. There are large start-up costs associated with transporting kelp and assembling an open pound structure for fishing, and it may be in the best interest of permittees to work together to utilize the smallest amount of gear to obtain the quota. HEOK is considered to be a low-impact fishery since there is no mortality of adult herring in the fishery, and the total amount of eggs that can be taken is restricted under a quota. Because of this, the Department sees no reasons to limit efficiency in this fishery.

The change to the process to designate a new Authorized Agent will bring the process in line with current practices, the form specified in the current regulations (MRD 164) is no longer used and form DFW 1406 will be used to designate and change agents.

Renewal Deadline
Adjusting the deadline brings the herring fishery in line with other fisheries in California. Previously, having a separate deadline meant additional work for License and Revenue Branch staff. Additionally, under the previous regulations License and Revenue Branch staff had to withhold permits until November 15 instead of issuing them as they received applications as is done in other fisheries. The change in renewal deadline is consistent with the deadline used in other fisheries in California and will increase permit processing efficiency. For the 2020 license year, the proposed regulation sets the deadline to renew at May 31, 2020, allowing an additional month for applicants to renew herring permits. For the initial year, a later deadline is needed because permits will not be converted until April 1, 2020 and additional public outreach is needed to ensure permitholders are aware of the changes in the permitting system and the renewal requirements.

Late fees and appeals process
Late fees for commercial fishing entitlements are specified in Fish and Game Code Section 7852.2, which is cross-referenced to aid in ease of finding the fees. Additionally, the appeals process for any denied permit renewals is outlined in specificity. The appeal and supporting information are submitted to the Commission in writing, along with a process to allow for the Department to respond to the appeal. Providing the information in writing helps clarify what issues are in play and expedite the appeal process. The 60-day timeline provides adequate time for a permittee to submit an appeal while still putting a limit on how long after denial an appeal can be submitted. The Department's 60-day response period similarly provides an adequate timeline for response while ensuring the next steps in the appeal process occur quickly. A similar procedure is used in other Department permitting contexts.

o **Add Subsection 163(d) Applications for New Permits.**

Proposed Changes
The current regulations specify the qualifying criteria and procedures for obtaining new herring permits across multiple subsections in 163 and 164. The proposed language in Subsection 163(d) now combines the new permit application requirements and procedures for all permit classes. This subsection also makes minor changes to the way the application process for new permits is described to make them consistent with modern regulatory and administrative procedures. The primary changes to the regulations governing applications for new permits include:

Permit Caps
The current regulations (Subsection 163(c)(1)) specify the following caps for each type of permit:

- No more than three permits shall be issued for Crescent City
- No more than four permits shall be issued for Humboldt Bay
- No new gill net permits shall be issued for the Tomales Bay permit area until the number of permits is less than 35
- No new odd- or even-numbered gill net permits shall be issued for San Francisco Bay until the number of permits is 160
- No new “DH” permits shall be issued until the number of permits is less than 80
- No new HEOK permits until the number of permits is less than 10

Proposed subsection 163(d)(1) and (2) specify caps on the total number of each class of permit that will be issued. The permit cap in Tomales Bay will be reduced from 35 to 15, and the permit cap under the new permit system in San Francisco Bay will be 30. The number of HEOK, Humboldt Bay, and Crescent City permits will stay the same.

Application Instructions
Current regulations combined application instructions for prior permittees and new applicants. Proposed subsections 163(d)(3) and (4) retain the process for submitting forms and fees for new applicants but reorganizes the requirements for clarity.

New Permit Application Deadline
The proposed language in subsection 163(d)(4) establishes the deadline for new applications as March 31, annually.

Random Selection Process
Current regulations specified that if there were more applicants than permits available, a random selection process would be held, but they did not specify how or when that selection process would take place. The proposed regulations retain the random selection process, but subsection 163(d)(5) now describes the process by which an applicant would be selected and notified.

Necessity and Rationale
Permit Caps
The new permit caps were developed in recognition that California's natural resources should be managed to maximize their long-term benefit to the state and its residents. The caps are intended to help maximize yield while maintaining stable quotas from year to year, minimize the number of years with a zero quota to maintain markets, and match the capacity of the fleet to the amount of take that the resource can sustain. Permit caps for each management area were set in relation to the precautionary quotas identified through the Herring FMP development process.

The Tomales Bay stock was assessed for many years and there is a good understanding of the average historical SSB. Through consultation with industry, the Department determined that a reduced permit cap of 15 permits would be economically optimal. For San Francisco Bay, Department biologists concluded that with the proposed, unadjusted 3,000-ton quota cap in the HCR framework, a fleet of 30 vessels could catch up to 100 tons of herring on average per vessel. Based on consultations with industry, this level of harvest is anticipated to maintain the economic viability of the fleet.

The new permit caps are long-term goals and will be achieved over time through natural attrition in the four management areas.

Application Instructions
The proposed changes are non-substantive to clarify and streamline the regulatory language.

New Permit Application Deadline
Adjusting the application deadline brings it in line with deadlines used in other fisheries, which makes the administrative process more efficient.

Random Selection Process
Including details on the random selection process provides clarity to applicants regarding how and when the process will be conducted, which matches how similar processes work in recreational hunting regulations.

- **Add Subsection 163(e) Conditions of the Permit.**

Proposed Changes
Currently, only herring permit conditions are addressed in Section 163, and HEOK permit conditions are found within Section 164. The proposed subsection 163(e)(1) combines the existing language in section 163 and 164 to state that Herring and HEOK may be taken under a revocable permit that has designated a fishing vessel. Subsection 163(e) goes on to clarify additional conditions for the Herring and HEOK sectors.

Herring
Current regulations specify that permittees can designate a substitute to fish for them under their permit and outline the application process and conditions associated with substitution. For herring, the proposed subsection 163(e)(2)(A) allows the permittee to have any licensed commercial fisherman serve in his place on a designated vessel and engage in fishing provided the permit is aboard.

HEOK
The current regulations describe the conditions of HEOK fishing in Section 164. These are moved to Section 163 and streamlined. The proposed subsection 163(e)(3) outlines that a copy of the permit must be aboard any vessel assisting in HEOK harvesting, processing, or transportation. Additionally, either the permit holder or an Authorized Agent must also be present.

Necessity and Rationale
Currently the conditions for utilizing each of the permits are found throughout sections 163 and 164. By collating and clarifying the permit conditions they will be easier to locate and comply with.

Herring
Permit substitution is a remnant of the old platoon system that caused permit holders to partner up on a single vessel. The proposed change to designate vessels under permits instead of approving substitutions achieves a shared goal between industry and the Department to eliminate paperwork and administrative burden while still maintaining accountability and flexibility within the fishery. For example, it allows permittees to have someone else fish in case of illness, but the permittee is still accountable for all violations committed under his/her permit, regardless of who is fishing (subsection 163(g) Revocation of Permits).

HEOK
The conditions for fishing under a HEOK permit are retained in the proposed regulatory changes. The only changes are organizational.

- **Add Subsection 163(f) Vessel Identification.**

Proposed Changes
Under the current regulations (Subsection 163(d)), any vessels engaged in herring fishing must display the fishing vessel number. The proposed language retains this requirement and adds additional language specifying the conditions of how numbers must be displayed.

Necessity and Rationale
Additional language specifying the conditions for how vessel numbers must be displayed, which are consistent with current regulation, is necessary to effectively implement the conditions of 163(g), which states that all permit holders are responsible for any violation committed by the vessel to which their permits are assigned. This will allow vessel numbers instead of permit numbers to be used to monitor and track fishing gear.

- **Add Subsection 163(g) Revocation of Permits.**

Proposed Changes
Current regulations specify penalties for violations in Section 163.5. Section 163.5 is proposed to be deleted and new penalties for violations are proposed to be described in subsection 163(g). Subsection 163(g) will now state that the Department has the authority to suspend or revoke a permit for any violation of the regulations of the terms and conditions of the permit. It also stipulates that a permit holder is liable for violations committed by any vessel operators or crew members fishing under the permittee's permit. Further, if a violation is committed by a permit holder who is currently fishing under another herring permit (as a crew member, vessel operator, or Authorized Agent), both permits may have the same enforcement action taken against them. The subsection also outlines the consequences and timelines associated with suspension and

revocation and describes the appeals process.

Necessity and Rationale
The existing language regarding penalties in Section 163.5 is somewhat atypical and does not reflect enforcement and penalty provisions common in other fisheries. This mainly reflects a prior agreement negotiated by permit holders in the late 1980s to maintain the ability to fish despite a violation, as suspension or revocation could be costly due to the high value and short season of herring fishery at that time. The penalty system outlined in Section 163.5 allowed permit holders to pay for violations using a point scheme and failed to effectively hold permit holders accountable. To address this, the proposed changes standardize the enforcement procedures to align with other California fisheries and ensure violators are held to the same standards as participants in other limited entry fisheries. This change is based on the basic premise that access to the fishery is a privilege and those that participate must be accountable to the regulations. Clear language on the conditions for permit suspension or revocation and stipulation that all permit holders are responsible for violations that occur under their permit, will serve to increase compliance in the fishery.

Additionally, the appeals process for any suspended or revoked permit is specified. The appeal, with supporting information, is submitted to the Commission in writing, beginning a process that allows for the Department to respond to the appeal. Providing the information in writing helps clarify what issues are in play and expedite the appeal process. The 60-day timeline provides adequate time for a permittee to submit an appeal while still putting a limit on how long after denial an appeal can be submitted. The Department's 60-day response period similarly provides an adequate timeline for response while ensuring the next steps in the appeal process occur quickly. A similar procedure is used in other Department permitting contexts.

o **Add Subsection 163(h) Permit Transfers.**

Proposed Changes
Current regulations governing transfers found in Section 163.1 are proposed to be deleted, and the conditions and procedures associated with permit transfers are proposed to now be described in subsection 163(h). Changes to the transfer process are:

- Proposed language in subsection 163(h)(2) directs permittees seeking to transfer a permit to submit a form DFW 1322-2 with the permit fee specified in subsection 705(b)(11).
- Proposed language in subsection 163(h)(2)(A) waives this fee for the transfer of any Temporary permit, as defined in proposed subsection 163(b)(1)(A).
- New language in subsection 163(h)(3) states that permits may not be transferred until any pending criminal, civil and/or administrative action has been resolved.
- New language in subsection 163(h)(4) gives a permit holder's estate up to two years after the permit holder's death to transfer the permit.
- Proposed language in subsection 163(h)(5) updates the appeals process to go straight to the Commission.

Necessity and Rationale
Proposed language specifying that permit transfers shall occur only as provided by regulations, including that the Department may deny transfer requests or revoke approved transfers for violation of relevant permit conditions, regulations, or Fish and Game Code, is consistent with current regulations.

Currently, transfer applicants are required to submit a notarized letter to the Department requesting a transfer and to pay a non-standard fee of $1,000 (Subsection 163.1(c)). The proposed regulations make the process consistent with other fisheries by referring to a form and fee identified in Section 705. The forms identified in Section 705 can be easily found and updated as necessary. Other new language in subsection 163(h) requiring all pending criminal, civil and/or administrative action to be resolved prior to transferring a permit increases overall accountability. Currently, there is nothing to prevent a permittee facing suspension or revocation from transferring their permit into someone else's name. Proposed language was therefore added at the request of Law Enforcement staff to make the transfer requirements consistent with those in other fisheries and to hold violators accountable. In the past, the Department has seen permits transferred before an active proceeding is resolved, thus allowing a potential violator to benefit monetarily and avoid the penalty of suspension or revocation. This section will allow all proceedings to finish before the Department makes a determination of whether or not someone is eligible for a transfer.

Waiving the transfer fee in instances of Temporary permit transfers eases any potential burden associated with proposed regulations in subsection 163(b)(1) that will automatically convert existing gill net permits to Temporary permits.

The timeline proposed in subsection 163(h)(4) provides the families of deceased permit holders adequate time to decide how to dispense with the permit, while still ensuring that these permits do not end up in an indeterminate state where they are not actively renewed nor transferred.

Under current regulations applicants who have been denied a transfer may appeal the decision within 60 days by submitting a letter to the San Francisco Bay Area Marine Region Office. If the denial of a transfer is sustained, the applicant may then appeal to the Commission. The proposed language in subsection 163(h) updates the appeals process so that permittees can appeal directly to the Commission. The appeal, with supporting information, is submitted to the Commission in writing. Providing the information in writing helps clarify what issues are in play and can expedite the appeal process. The 60-day timeline provides adequate time for a permittee to submit an appeal while still putting a limit on how long after denial an appeal can be submitted. The Department's 60-day response period similarly provides an adequate timeline for response while ensuring the next steps in the appeal process occur quickly. A similar procedure is used in other Department permitting contexts.

- **Add Subsection 163(i) Research.**

Proposed Changes
Current regulations in Section 163 outline the conditions under which permittees may assist the Department in research. The proposed language in subsection 163(i) allows the Department to authorize permittees to take herring during a closed season or in a closed area, subject to such restrictions regarding gear(s), date(s), location(s), time(s), size, poundage, or other matters as specified by the Department. Participants must provide data and/or samples to the Department as outlined in the authorization letter.

Necessity and Rationale
Although the monitoring protocol identified in the Herring FMP is primarily designed to be carried out by Department staff, its efficacy will be greatly increased through collaboration with fishermen. Department resources are limited and must be allocated where there is the greatest need. Collaboration with key partners could be a useful tool to provide information in areas where the Department lacks the resources to monitor herring populations. The proposed change provides an avenue for collaborative research with permittees, while retaining management

integrity and Department control.

- **Delete the Existing Regulations (including subsections a-e) in Section 163.1 Title 14, CCR, Herring Permit Transfers; and replace with Harvest of Pacific Herring**

Proposed Changes
The regulations currently in Section 163.1 Herring Permit Transfers are deleted and replaced with Harvest of Pacific Herring. Herring permit transfers are fully described in the amended provisions of Section 163.

Necessity and Rationale
The current provisions provide definitions and specify a process for transferring permits within the former system of platoons. However, given that the proposed regulations eliminate the platoon system, this language is now obsolete. The proposed provisions carefully lay out the methods for harvest of herring.

- **Section 163. Harvest of Pacific Herring.**

- **Add Subsection 163.1(a) Harvest of Pacific Herring.**

Proposed Changes
Current regulations (subsection 163(f)) describe the areas where herring may be taken for commercial purposes, and which locations are closed to herring fishing within those areas. The proposed subsection 163.1(a) makes no substantive changes to the areas that can be fished. However, these regulations have been reorganized and edited for clarity.

Necessity and Rationale
Spatial restrictions provide protection for herring spawning habitat. For example, Richardson Bay is considered a conservation area and has never been open to commercial gill net herring fishing. Since subtidal spawn deposition surveys began, a majority of observed spawns have occurred in Richardson Bay. This closure therefore protects herring during spawning in one of the most important spawning areas in San Francisco Bay. Other closures, like that in the Central Bay, protect deep-water areas that herring utilize prior to spawning. This regulation also helps Department staff to locate and monitor HEOK fishing activity. However, no substantive changes to these areas are being proposed and the proposed regulations only make organizational and minor editorial changes for clarity.

- **Add Subsection 163.1(b) Fishing Season.**

Proposed Changes
Current regulations (subsection 163(h)) describe four different season dates for San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Harbor. The proposed regulations instead create a standard start date of January 2 at 5:00 p.m. and a standard end date of March 15 at noon.

Necessity and Rationale
Currently, the herring fishery seasons are: January 1 through March 15 in San Francisco Bay; December 26 through February 22 in Tomales Bay; January 2 through March 9 in Humboldt Bay; and January 14 through March 23 in Crescent City. HEOK is open from December 1 through March 31. The Department conducted a review of these existing regulations and sought input from various stakeholder groups, including permit holders, processors, Law Enforcement staff, recreational fishermen, and the conservation community through surveys, meetings, and public comment periods. The feedback led to the proposal of a single start (January 2) and end (March 15) date for all management areas. The proposed change makes enforcement, management, and quota tracking more efficient and simpler across all of the management areas.

- **Add Subsection 163.1(c) Gear Requirements.**

Proposed Changes
Current regulations (subsection 163(f)) describe the type of gear that may be utilized to take herring for commercial purposes, including length of nets and mesh size, the process for measuring gill nets, and marking requirements. Proposed subsections 163.1(c)(1-3) retain these requirements with no changes other than reorganization and editing for clarity.

The current regulations specify that gill nets must be marked with their permit numbers. Proposed subsection 163.1(c)(4) now specifies that rather than being marked with permit numbers, nets must be marked with the number of the fishing vessel they are being fished from.

Necessity and Rationale
When the herring sac roe fishery first began there were no restrictions on gear type. However, since the 1970s a variety of gear restrictions were established including a transition from round haul to gill net, reduction in amount of gear allowed to be fished per permit, and adjustments in gill net mesh size. Because gear restrictions evolved over many years of regulatory changes, the current regulations related to gear are found throughout different sections, making them difficult to locate. The proposed reorganization of the regulatory language streamlines and clarifies gear requirements. No changes to the mesh size allowed are proposed at this time given that the catch has primarily consisted of age 4+ herring with the current gill net mesh size of 2 inches, which is consistent with the Department’s goal of ensuring that all herring are able to spawn prior to becoming vulnerable to the fishery.

The proposed change requiring nets to be marked with the number of the fishing vessel they are being fished from rather than being marked with permit numbers is necessary to maintain consistency with the proposal to eliminate the platoon system in San Francisco Bay, as this will cause permit numbers to change as permit holders consolidate Temporary permits into a single permit – the San Francisco Bay Herring permit. The proposed regulations in subsection 163(g) state that all permit holders are responsible for any violation committed by the vessel their permits are assigned to. Given this, there will be no need to track the specific permit numbers associated with each gill net and instead vessel numbers will be used to monitor and track fishing gear.

The proposed change simplifies tracking in the event of a violation. Instead of needing to look up vessel number associated with a permit number, enforcement can see the vessel associated with the violation, intercept it, and issue a citation.

Proposed language requiring lighted marker buoys at each end of any gill net used is consistent with current regulations.

- **Add Subsection 163.1(d) Net Tending.**

Proposed Changes
Current regulations (subsection 163(f)(2)(A)) require that vessels fishing for herring in San Francisco Bay cannot be more than three nautical miles from their net at any time. The proposed subsection 163.1(d) reduces this to a distance of one nautical mile.

Necessity and Rationale
The change is proposed to ensure that permittees are close enough to their gear to be easily located by Law Enforcement staff should their gear be set in such a way that constitutes a violation of the regulations. Additionally, it will reduce the loss of nets, which can lead to ghost fishing, as well as allow permittees or their vessel operators and crew to respond quickly should a marine mammal or sea bird become entangled in a net.

- **Add Subsection 163.1(e) Temporal Closures.**

Proposed Changes
Current regulations (subsection 163(h)(5)) states that fishing for herring in San Francisco Bay is not permitted from noon Friday through 5:00 p.m. Sunday night. The proposed subsection 163(e) extends this regulation to all herring permit areas.

Necessity and Rationale:
In San Francisco Bay, weekend restrictions are in place for the commercial herring fishery to prevent conflicts between user groups, primarily recreational boaters that frequent the bay beginning on Friday. The proposed change extends the same weekend restriction to Tomales Bay, Humboldt Bay and the Crescent City Harbor where commercial herring fisheries are currently permitted to fish seven days per week. The proposed regulation change reduces conflict between herring fishers and other user groups in these areas, while also reducing weekend enforcement needs. Additionally, the change provides a temporal refuge for spawning runs, and thus allows for some escapement and possibly limiting fishing pressure on some schools of herring.

- **Add Subsection 163.1(f) Noise.**

Proposed Changes
Current regulations (subsection 163(f)(2)(H)) require all participants fishing in San Francisco Bay comply with existing noise ordinances when within 500 meters of a shoreline between the hours of 10:00 p.m. and 7:00 a.m. The proposed regulations move that requirement to subsection 163.1(f) but makes no other substantive changes.

Necessity and Rationale
Relocation of the regulation is necessary due to the proposed reorganization of the commercial herring regulations.

o **Add Subsection 163.1(g) Marine Mammals.**

Proposed Changes
Current regulations (subsection 163(f)(2)(G)) specify that no marine mammal deterrents may be used in San Francisco Bay. The proposed language in 163.1(g) extends this regulation to all management areas where herring are fished.

Necessity and Rationale
Herring nets can attract marine mammals, particularly seals and sea lions. To reduce possible negative interactions, marine mammal deterrent devices like explosives have been used in some places. Use of these devices is currently prohibited inside the waters of San Francisco Bay during the herring season. The proposed regulations extend this prohibition to other areas where herring are fished. The goal is limit impacts to marine mammals and to avoid conflicts and/or harm to other user groups. No other changes are recommended beyond relocating the existing language to the proposed subsection 163.1(g).

o **Add Subsection 163.1(h) Retention and Discards.**

Proposed Changes
Current regulations (subsection 163(e)(4)) require all fish caught while fishing for herring to be retained and landed except for a suite of sensitive species including sturgeon, halibut, salmon, steelhead and striped bass. These must be returned to the water immediately as specified in subsection 163(e)(6). The proposed subsection 163.1(h) makes no changes to this regulation other than reorganizing it.

Necessity and Rationale
This proposed change would simply reorganize and edit the existing regulatory language to improve overall clarity, without substantive changes.

o **Add Subsection 163.1(i) Notification Requirements.**

Proposed Changes
Current regulations (subsection 163(e)(2)) require permittees to notify staff at the Santa Rosa Marine Region office if they stop fishing before the season has ended. The proposed subsection 163(i) retains this regulation and requires permittees to notify the Department when they begin fishing for the season. In addition, these regulations indicate that permittees should utilize the contact information on the permit rather than the Santa Rosa Marine Region telephone number.

Necessity and Rationale
The existing regulation was outdated, and the proposed change provides current contact information. The change also provides more flexibility by allowing the Department to alter the office locations based on staff availability or other future changes, as well as modernizes communication options by allowing the potential use of a website for contact. Extending the requirement to include notifications at the beginning and cessation of fishing helps the Department track quotas in a smaller fishery where participants may not be fishing every year. It also helps the Department track permittees who may be targeting herring for the whole fish market rather than the sac roe market.

- **Add Subsection 163.1(j) Landing Requirements.**

Proposed Changes
Current regulations specify the landing requirements for the fishery, including a restriction on landing herring between the hours of 10:00 p.m. and 6:00 a.m., as well as on weekends (subsection 163(j)(4)(C)); restrictions on transferring herring to another boat or leaving unlanded herring unattended (subsection 163(e)(4)); a requirement that herring must be delivered to someone with a Herring Buyer's permit (subsection (e)(1)); regulations describing how the Department will manage the fishery as the quota is approached (subsection 163(e)(2)); and a requirement that any herring caught in excess of the quota must be forfeited to the Department (subsection (e)(5)). All of these restrictions are retained in the language proposed in subsection 163.1(j). The primary change to this section is organizational, with all landing requirements grouped into the same subsection for ease of use. In addition, the restriction on landing herring between the hours of 10:00 p.m. and 6:00 a.m., or on weekends, is extended to all herring fishing areas.

Necessity and Rationale
Landing requirements are mainly intended to help the Department track commercial catch relative to the quota and determine when the quota has been reached. A quota-managed fishery such as herring requires staff to be able to track landings in near or real-time to avoid overages. In San Francisco Bay, herring can only be unloaded between 6:00 a.m. and 10 p.m. Monday through Friday. This restriction was put in place to reduce the noise associated with herring offloading pumps near residential areas such as those in Sausalito, but it also helps Department staff with enforcement and quota monitoring by reducing staffing needs in the middle of the night or on weekends. In the past, this has meant staff needed to be at the docks to meet the boats and collect weight tally sheets from buyers as the boats unloaded. Because of the ability of staff to attend to vessels during off-loading in Tomales and San Francisco bays, the fisheries in these areas were able to achieve very precise quota attainments. The proposed change extends the restriction used in San Francisco Bay that limits the times herring can be unloaded to all the management areas. This change will help Department staff more accurately track the quota across all areas, as well as reduce enforcement needs at night. Proposed regulations describing Department estimation of catch rate, announcement of temporary closure, allotment of remaining quota among permittees, and forfeit of any fish landed in excess of established quota is consistent with current regulations. Grouping herring landing requirements into the same subsection improves the overall clarity of the regulations.

- **Delete the Existing Regulations (including subsections a-f) in Section 163.5 Title 14, CCR; Penalties in Lieu of Suspension or Revocation - Herring Permittees; and replace with Herring Buyers Permit.**

Proposed Changes
Delete current Section 163.5 and instead rely on the proposed regulatory language, subsection 163(g) that specifies the conditions under which permits can be suspended or revoked, and who is accountable for various violations, and the procedure for appealing a suspension or revocation. Subsection (a) of proposed Section 163.5 will instead describe the regulations associated with the Herring Buyer's permit.

Necessity and Rationale
Current regulations in Section 163.5 describe a system of fines associated with various violations in the herring fishery in lieu of suspension and revocation of the permit. This system is no longer relevant to the fishery and the associated regulations will be deleted. The proposed

change to delete this section and instead rely on the proposed subsection 163(g). As discussed above, this change standardizes the enforcement procedures in the Herring fishery to be consistent with other fisheries and makes certain that violators in the fishery are held to the same standard as in any other limited entry fishery in California.

- **Section 163.5. Herring Buyer's Permit**

- **Add 163.5(a) Pacific Herring Buyer's Permit.**

Proposed Changes
The proposed language in subsection 163.5(a) is largely reproduced from subsection 163(j) of the current regulations and has been slightly edited for clarity. In addition, because subsection 164(h) on HEOK landing requirements is proposed to be amended to require that all receivers of HEOK have a Herring Buyer's Permit (the form Herring Buyer's Permit Application DFW 327 (Rev. 4/11/19) is found in 705(a)(3)), additional changes to the language have been made to apply to receiving herring and HEOK.

Necessity and Rationale
This change is necessary to align with the proposed redrafting of Section 163 as well as the proposed language in subsection 164(h). Extending the Herring Buyer's permit to the HEOK sector is necessary to assist the Department in tracking the catch and determining when the quota has been reached in a timely manner.

- **Delete the Existing Regulations (including subsections a-n) in Section 164 Title 14, CCR; Harvesting of Herring Eggs; and replace with Harvest of Herring Eggs on Kelp.**

Proposed Changes
Current regulations in Section 164 describe the requirements for obtaining a permit to take HEOK in San Francisco Bay. Requirements include holding a current gill net permit pursuant to the regulations in Section 163 and electing to designate that permit for use in the HEOK fishery. This section also specifies the allowed methods of take as well as landing and processing requirements. The proposed changes, which are described in detail in the following sections, include the following changes:

- Bring HEOK fees in line with those paid by the gill net sector
- Streamline notification requirements
- Clarify vessel identification requirements
- Clarify cork line identification requirements
- Remove weekend harvest restrictions for the HEOK sector
- Require that anyone receiving HEOK require a Herring Buyer's permit to assist the Department in tracking quotas.

Some sections are proposed to be deleted without replacement. These deletions include:

- Subsection 164(g)(2): language related to royalty fee
- Subsection 164(g)(3): language related to Herring-Eggs-on-Kelp Monthly Landings and Royalty Report (DFW 143 HR (REV. 06/04/15)
- Subsection 164(i): language related to the performance deposit
- Subsection 164(j): language related to raft size specifications prior to 1995
- Subsection 164(k)(4): language related to weekend off loading if Department is reimbursed

- Subsection 164(j)(2): language on the test fishery

All other changes are non-substantive and only seek to improve the organization and clarity of the regulations.

Necessity and Rationale

In the late 1980s when the HEOK fishery began and limited entry permits were first being issued, gill net permittees were given priority over new entrants provided they forfeited their right to fish in the gill net fishery. This was done to remove fishing effort from the gill net fishery, which at the time was at an all-time high. Because of this, anyone fishing for HEOK was subject to current regulations in both sections 163 and 164. Since the beginning of the HEOK fishery, regulations have been amended more than 30 times in an ad-hoc fashion as the fishery evolved and issues arose. The proposed Herring FMP provides an opportunity to streamline and modernize the regulatory language to make it consistent with the administrative and enforcement procedures that are currently used by the Department.

Proposed deletion of the regulatory language (subsection 164(g)(2) and 164(i)) will align the fees of the HEOK fishery with those paid in the gill net fishery. Current fees reflect a previous effort by HEOK participants to discourage new participants from joining the fishery as few new entrants had the resources to put up the 50% performance deposit required prior to the start of the season. Current regulations also state that HEOK permit holders must pay a royalty of $500 per ton of HEOK taken and the landing fee. This is significantly more than the landing fee ($5.40/ton) paid by the gill net fleet. By deleting this language, the proposed regulations will eliminate the need for HEOK participants to pay additional fees beyond the standard landing fee.

Current regulations (subsection 164(j)) specify that rafts used in the HEOK fishery prior to the 1995-1996 season (when the current raft size restriction was created) are exempt from the size specifications. None of these rafts are currently used in the fishery and this language is now obsolete.

Current regulations (subsection 164(k)(4)) also state that HEOK may be harvested on Saturdays and Sundays at any time if the permittee reimburses the Department for the cost of operations. However, the Department has no mechanism to process reimbursements and therefore these regulations were never operable. The proposed regulations would therefore delete this language. HEOK permittees will now be allowed to harvest at any time (assuming the notification requirements in proposed subsection 164(e) have been met) but can only land herring eggs between 6:00 a.m. and 10:00 p.m. during the week.

Lastly, current regulations (subsection 164(j)(2)) specify the conditions under which a test fishery for HEOK may occur. These regulations were originally developed to allow fishermen to determine where and when a spawning event may occur. After consultation with industry representatives it is proposed that this regulation be deleted, as the fleet does not use them because they are not an effective way to predict spawns. A more effective way would include taking small test samples of herring, which could be allowed under the proposed language in 163(i). Per the proposed regulation, this test fishery could be structured to also assist the Department with data collection.

- o **Section 164. Harvest of Herring Eggs on Kelp.**
- o **Add Subsection 164(a) Definitions.**

Proposed Changes
The current regulations (subsection 164(e)) specify definitions related to the allowed method of take for the HEOK fishery. Proposed subsection 164(a) would retain these definitions but reorganize them and add additional definitions for further clarification of proposed regulations in this section, in such a manner as is consistent with current regulations.

Necessity and Rationale
The proposed reorganization only clarifies and streamlines the existing regulations.

- **Add Subsection 164(b) Area Restrictions.**

Proposed Changes
Current regulations in Section 164 describe the areas where HEOK may be taken for commercial purposes, and which locations are closed to herring fishing within those areas. The proposed subsection 164(b) makes no changes to the areas that can be fished. However, these regulations have been reorganized and edited for clarity.

Necessity and Rationale
The proposed reorganization clarifies and streamlines the existing regulations.

- **Add Subsection 164(c) Fishing Season.**

Proposed Changes
The current regulations state that the HEOK fishing season goes from December 1 to March 31 (subsection 164(b)). The proposed subsection 164(c) retains these dates.

Necessity and Rationale
There is no change proposed beyond reorganization.

- **Add Subsection 164(d) Gear Requirements.**

Proposed Changes
Current regulations (Subsection 164(j)) describe the type of gear that may be utilized to take HEOK for commercial purposes, including size of rafts and length of cork lines. The current regulations also describe the marking requirements for gear, as well as restrictions on the amount of gear each permittee may use. The proposed language does not change the amount of gear each permittee can use, but Subsection 164(d)(1) re-words these requirements for clarity.

Additionally, proposed Subsection 164(d) retains the language specifying the maximum dimensions and marking requirements for rafts, but eliminates language allowing rafts in use prior to 1996, which may be larger than the 2,500 square feet. The proposed change also requires rafts to display the fishing vessel number the permit has been assigned to rather than the permit number. Proposed Subsection 164(d) specifies the dimensions and marking requirements for cork lines, including a change that requires signage to mark cork lines. Current regulation (Subsection 164(j)(1)) requires that cork lines be marked with a large sign indicating the permit number the line is being fished under, while the proposed language in Subsection

164(d)(1)(F) requires that cork lines should be marked with a contrasting-colored buoy displaying the official number of the vessel from which such net is being fished with Roman alphabet letters and Arabic numerals at least 2 inches high.

Necessity and Rationale
There are no longer any rafts used that date back to 1996 or earlier, and thus the regulatory language associated with restriction on such rafts is no longer necessary.

As in the gill net fleet, it is proposed that gear will no longer be required to be marked with permits numbers. Instead, gear will be marked with the fishing vessel number of the boat the permit has been assigned to. Because multiple permits can be assigned to the same raft, this change requiring a single fishing vessel number to be displayed is simpler and easier to comply with. The proposed change also simplifies tracking in the event of a violation. Instead of needing to look up vessel number associated with a permit number, Law Enforcement staff can see the vessel associated with the violation, intercept it, and issue a citation.

Current regulations require that cork lines be marked with a large sign that is 14-inch high with 2-inch wide letters, which is cumbersome. The proposed regulations would require the ends of cork lines to instead be marked with a buoy which will make laying out lines and hanging kelp easier. The proposed marking requirements were recommended by Law Enforcement staff and are consistent with how herring gill nets are marked. Under this change it will still be possible for enforcement to identify the location of cork lines and identify what vessel and permit the line is associated with. Lastly, the proposed reorganization simply streamlines and clarifies the language associated with gear requirements, including marking and lighting.

- **Add Subsection 164(e) Notification Requirements.**

Proposed Changes
Current regulations state that HEOK permittees must notify the Department at four different times during the fishing process, and again if anything changes. These are summarized below:

- Within a four-hour period prior to hanging kelp (Subsection 164(i)7)
- At least 12 hours prior to harvesting on a weekday (Subsection 164(k)2)
- During normal business hours (8am to 5pm) prior to harvesting on a weekend (Subsection 164(k)4)
- At 12 hours prior to removing bins or totes from processing facility (Subsection 164(k)9)

The proposed Subsection 164(e) reorganizes the notification requirements into one area of the regulations and standardizes the timeframe among activities requiring notification. The proposed notification process includes:

- A single point of contact that will be specified on the HEOK permit
- Notification is required within 12 hours of the following activities:
    1) The suspension of kelp on a raft and/or lines
    2) Harvest of HEOK
    3) Landing of HEOK
- Elimination of a separate requirement for notification of weekend harvest
- Requirement for permittees to supply the following information:
    1) Vessel number
    2) Departure point of vessel
    3) Location of each raft/line

4) Estimated suspension/landing/harvest time
5) Point of landing
6) A contact number where the permittee or their Authorized Agent can be reached

- Requirement to re-notify the Department if any of the preceding change

Necessity and Rationale
The proposed changes related to providing contact and notification information on the permit allow the Department to alter the notification process without having to change regulations. The change standardizes the notification requirements and timeframe. It also ensures that regulations related to notification requirements are clear, reasonable, and relevant to Law Enforcement's needs. Lastly, reorganizing the requirements into one area improves access and overall clarity.

- **Add Subsection 164(f) Noise.**

Proposed Changes
There are no restrictions on noise that apply to HEOK fishing activities in the current regulations. Proposed Subsection 164(f) extends the same noise restrictions that apply during gill net fishing to HEOK participants.

Necessity and Rationale
HEOK fishing also takes place close to shorelines with residential units, and in order to prevent conflict between residents and other user groups, the noise requirements are proposed to be extended to the HEOK fishery as well. This will help maintain consistent regulations between the two sectors.

o **Add Subsection 164(g) Marine Mammals.**

Proposed Changes
Currently the regulations in Section 163 specify that no marine mammal deterrent devices may be used in San Francisco Bay during Herring fishing. The proposed regulations retain this restriction and includes it in Section 164 to apply it to the HEOK sector.

Necessity and Rationale
Herring spawning on kelp suspended from rafts and lines can attract marine mammals, particularly seals and sea lions. The Department aims to limit any negative interactions between the fishery and marine mammals, and therefore it is proposed to extend the restrictions on the use of marine mammal deterrent devices, such as explosives or "seal bombs", established for the San Francisco Bay gill net fishery to all management areas and the HEOK fishery. The proposed change also reduces the potential for marine mammal deterrent device usage to impact or interfere with other users in high visibility and high traffic areas.

- **Add Subsection 164(h) Landing Requirements.**

Proposed Changes
The current regulations (Subsection 164(k)) outline landing requirements for HEOK. The proposed language in Subsection 164(h) retains this language but makes two substantive changes. The first is a prohibition on landing HEOK on weekends (10:00 p.m. Friday to 6:00 a.m. Monday) in proposed subsection (h)(4). The second is a requirement that anyone receiving HEOK must have a Herring Buyer's permit. Other changes to this subsection are organizational.

Necessity and Rationale
The proposed landing requirements will improve the Department's ability to track the catch relative to the quota and determine when the quota has been reached. Quota managed fisheries, like the HEOK fishery, requires staff to be able to track landings in near-real time. Due to staffing constraints it has been difficult to track offloading at night and on weekends. Additionally, the Herring Buyer's permit, which requires buyers to report landings to the Department within 24 hours, also assists the Department in tracking catches in a timely manner. This remains necessary because under the transition to electronic landings reporting pursuant to Title 14 Section 197, only the sablefish and groundfish fisheries are required to report landings within 24 hours. All other fisheries are required to report landings within three days, and this could lead to an overage of the quota in the herring fishery.

o **Add Subsection 164(i) Processing Requirements.**

Proposed Changes
Current regulations (Subsections 164(e)(3) and 164(k)(5)) specify the processing requirements for HEOK. Proposed Subsection 164(i) retains these provisions and only makes non-substantive, organizational changes.

Necessity and Rationale
No changes are proposed other than organizational changes for clarity and ease of access.

o **Amend Section 705. Commercial Fishing Applications, Permits, Tags, and Fees.**

Proposed Changes
- Amend subsection (a)(3), adding Herring Buyer's Permit Application DFW 327 and updated fee;
- Amend subsection (a)(4), application form DFW 1406 and fees for Herring Eggs on Kelp (HEOK);
- Delete subsection (a)(5), FG 329 and fee, there will no longer be a Herring Fresh Fish Permit;
- Amend subsection (a)(6), Commercial Herring Permit Worksheet DFW 1377, adding new permit fees by location for commercial herring, and a new Drawing Fee in (a)(6)(E) for applying for new permits in accordance with 163(d).
- Amend subsection (b)(11), application form DFW 1322-2 and a new fee for Permit Transfers in accordance with 163(h).

Necessity and Rationale
The current forms used for the herring fishery have been deleted with the former regulatory text, however, the forms themselves have not undergone significant change. The new forms dated 4/11/19 have an updated form number "DFW" (Department of Fish and Wildlife) and may have small formatting changes.

Because of the adoption of the Herring FMP, and the adoption of the amendments to the herring regulations as described herein, the forms are necessary for application with the new regulations.

- (a)(3) –The form 2019-2020 Herring Buyer's Permit Application DFW 327 (New 04/11/19) is incorporated by reference and provides necessary information to evaluate the request. The fee is updated according to FGC Section 713.
- (a)(4) –The form Herring-Eggs-On-Kelp Permit Application DFW 1406 (New 04/11/19) is

incorporated by reference and provides necessary information to evaluate the request. The fee is updated according to FGC Section 713. (*Fees: see note below)

- (a)(5) - deleted, in 2013 regulations were changed to eliminate distinctions between whole fish and sac roe fishery sectors, effectively allowing herring to be landed for either purpose, at any time during the roe fishery, therefore the available herring quota can be caught and sold for either roe or fresh fish purposes, eliminating the need for a separate form FG 329 and fee.
- (a)(6) - The form Commercial Herring Permit Worksheet DFW 1377 (New 04/11/19) is incorporated by reference and provides necessary information to evaluate the request. The fee is updated according to FGC Section 713. (*Fees: see note below)
- Subsection (a)(6)(E) establishes a small processing (Drawing) Fee for participating in a Department drawing for available new permits. The calculation of the proposed fee is provided for in the Economic Impact Analysis of this ISOR.
- (b)(11) - The form Season Request For Changes To Herring Permits: Boat Transfer & Simultaneous Fishing DFW 1322-2 (New 4/11/19) is incorporated by reference and provides necessary information to evaluate the request.
- Subsection (b)(11)(A) deletes the Temporary Substitute fee and adds the Permit Transfer Fee of $1000. (**Fee: see note below)

* Note: Under Fish and Game Code Section 710.5(b), it is the legislature's intent for the Department's operation to be funded by the fees collected from the users of wildlife resources. The resident and non-resident fees for the commercial herring fishery are moved from Fish and Game Code Section 8550.5 (made inoperative under the new Section 55, pursuant to FGC 7071(b)) to Section 705. The fees have been and will be subject to annual indexing per FGC Section 713. The fees for herring and HEOK applicants are equal, $401.50 for residents, and $1,494.00 for non-residents. Also note that the commercial license and boat registration fees are not subject to this rulemaking and appear on the forms as a convenience to the public.

** Note: The permit transfer fee of $1000 is moved from the current subsection 163.1(a) (text deleted) to Section 705.

The forms are Incorporated by Reference and attached hereto with the Regulatory Text, per Administrative Procedures Act requirements:

(1) The Department will demonstrate in the final statement of reasons that it would be cumbersome, unduly expensive, or otherwise impractical to publish the documents in the California Code of Regulations.
(2) The Department will demonstrate in the final statement of reasons that the documents were made available upon request directly from the Department and were reasonably available to the affected public on the Department website Wildlife.ca.gov.
(3) The informative digest in the notice of proposed action clearly identifies the documents to be incorporated by title and date of publication or issuance.
(4) The regulation text states that the documents are incorporated by reference and identifies the document by title and date of publication or issuance.
(5) The regulation text specifies that the forms are being wholly incorporated by reference.

(b) Goals and Benefits of the Regulation:

Herring support an important and historically significant commercial fishery in California. They are also a critical food source for many predatory fish, marine mammals, and seabirds within the California Current Ecosystem. Their biological and economic importance led the Department to develop the proposed Herring FMP to help ensure the long-term health of the resource. Specifically, the goal of the Herring FMP is to formalize a management strategy that is responsive to environmental and socioeconomic changes and establishes a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem. To achieve this goal, the Department outlined a number of management objectives for the FMP process, including:

- Overhaul the limited entry permit system to reflect the needs of the modern herring commercial fleet.
- Modernize and streamline existing herring regulations and the annual quota-setting process.
- Develop a HCR for the San Francisco Bay fishery that sustains a commercial fleet, accounts for ecosystem considerations, and reflects current precautionary management.
- Develop regulations for the recreational herring fishery.
- Develop collaborative research protocols and requirements for resuming commercial Herring fishing activities in Tomales Bay, Humboldt Bay, and Crescent City Harbor.
- Encourage collaborative fisheries research to help fill data gaps and integrate the perspectives and expertise of industry members and other stakeholders in the management process.

Implementing the Herring FMP is expected to have wide-ranging social, economic, and ecological benefits. However, to implement the management changes described in the Herring FMP, it is necessary to amend the existing regulations which were drafted decades ago when the fishery was much larger than it is today. When the fishery initially developed, the high value of sac-roe quickly drove up participation levels and increased competition for space in San Francisco Bay. This required intensive management and regulations changed annually as the fishery expanded. Many of these regulations were designed to address socio-economic rather than biological issues. However, price and participation have continued to decline over the past 20 years and many of the regulations intended to manage a much larger fleet are now obsolete and should be deleted. Other regulations are still relevant but need to be updated. A few new regulations need to be created, such as those for the recreational fishery. To that end, the Department has prepared a comprehensive suite of proposed amendments, which are described in this document. These amendments will have the following benefits:

- A more precautionary approach to setting quotas that adjusts the level of risk based on the amount of data collected, while also scaling management effort to the activity level of the fishery.
- Improved transparency in management via a clear, pre-determined HCR process that allows the Department to efficiently set quotas each year.
- Appropriate permit caps within the four management areas that are based on what is sustainable for the Herring stocks and economically optimal for the permit holders.
- Reduced complexity in the permitting system in San Francisco Bay, which was developed for a much larger fleet.

- Separation between the HEOK and gill net permits, so that any future changes deemed necessary for the management of either sector does not trigger a change in the other sector.
- Restored parity in the fees paid between the sectors.
- Standardized enforcement procedures to align with other California fisheries and strengthen accountability within the herring fishery.
- Establishment of uniform season dates for all four management areas, making enforcement, management, and quota tracking easier.
- A mechanism for regulating and estimating the amount of catch in the recreational sector, which currently does not exist.
- More efficient use of Department staff time by transferring quota setting authority from the Commission to the Director of the Department under the management strategy outlined in the Herring FMP.
- Modernized permit application, renewal, and transfer processes that are consistent with current practices in the Department.
- Establishment of a regulatory mechanism that can incentivize collaborative research between the Department and stakeholders.
- Streamlined regulations that standardize fishing and permitting practices across all areas and sectors of the fishery.
- Reorganized regulations that provide language that is clear, easy to follow, and enforceable.

(c) Authority and Reference:

§ 27.60 Authority: Sections 200, 205, 7071 and 8587.1, Fish and Game Code.
Reference: Sections 205, 7071, 7120, and 8587.1, Fish and Game Code.

§ 28.60 Authority: Sections 200, and 205, Fish and Game Code.
Reference: Section 205, Fish and Game Code.

§ 28.62 Authority: Sections 200, and 205, Fish and Game Code.
Reference: Sections 200, and 205, Fish and Game Code.

§55.00, 55.01 and 55.02:
Authority: Part 1.7 and Article 15, Fish and Game Code.
Reference: Part 1.7 and Article 15, Fish and Game Code.

§ 163 Authority: Sections 7071, 7078, 8389, and 8550, Fish and Game Code.
Reference: Sections 7071, 8389, and 8550, Fish and Game Code.

§ 163.1 Authority: Sections 7071, 7078, and 8550, Fish and Game Code.
Reference: Sections 7071, 7078, and 8550, Fish and Game Code.

§ 163.5 Authority: Sections 7071, 8032.5, and 8389, Fish and Game Code.
Reference: Sections 7071, 8032, 8032.5, 8033, and 8389, Fish and Game Code.

§ 164 Authority: Sections 7071, 7078, 8389, and 8550, Fish and Game Code.
Reference: Sections 7071, 8389, and 8550, Fish and Game Code.

(d) Specific Technology or Equipment Required by Regulatory Change: None.

(e) Identification of Reports or Documents Supporting Regulation Change:

Attachment 1: Draft 2019 California Pacific Herring Fishery Management Plan.

(f) Public Discussions of Proposed Regulations Prior to Notice Publication:

Herring FMP Steering Committee
A new model of FMP development was used to create the Herring FMP in which a small group of stakeholders representing various interest groups worked with Department scientists and managers to develop the scope of the Herring FMP and provide guidance along the way. The SC was formed out of an informal discussion group that had been meeting since 2012 to discuss the management needs of the Herring fishery. This group, which included herring fleet leaders, conservation NGO staff, and Department staff, produced a draft process blueprint, timeline and budget for the Herring FMP, identified a Fiscal Agent, and raised funds for outside consultants to manage the Herring FMP development process. In order to develop a management plan that had the support of all SC members, regular meetings were held with the SC to provide updates on progress and receive guidance on how to proceed. Throughout the process the Department retained authority over the final contents of the Herring FMP, and approval for final submission to the Commission.

Public Scoping Process
Once the Herring FMP development process was initiated, a document describing the intended scope of the project was widely distributed to alert stakeholders of the management issues to be addressed. This scoping document was distributed to the public via a number of channels, including by mail to current permit holders, on the Department’s Marine Region Management News website, as well as on the Herring Management blog, and via email to the Director’s Herring Advisory Committee (DHAC) members and any other interested parties that email addresses were available for. The scoping document also was distributed to 120 federal and 13 state tribes. The results of the scoping process were presented to the Marine Resources Committee (MRC) at a public meeting in March 2017 for guidance and support for the intended scope. The MRC adopted the intended scope, which guided the remainder of the Herring FMP development process.

Commercial Permit Holder Meetings and Survey
Each year the Department meets with the DHAC. During the Herring FMP development process these meetings provided opportunities to provide updates on the progress of Herring FMP to the herring fleet and other interested attendees. While these meetings focused primarily on changes affecting the San Francisco Bay gill net sector, additional one-on-one meetings were also held with representatives of the smaller sectors to ensure that the needs of these sectors were being addressed. The Department also sought feedback from the fleet on potential regulatory changes via a survey that was mailed to all permit holders. Based on the survey results, the Department worked with the Herring FMP Project Management Consultant Team to develop a draft proposal for regulatory changes that had broad support. A meeting for all permit holders was held in January 2018 (coincidental with the herring season to maximize attendance), and the draft regulatory change proposal and management strategy for setting herring quotas were presented to the fleet. At this meeting, permit holders had the opportunity to ask questions and provide comments. The meeting was also broadcasted via webinar to enable remote participation.

Commission and MRC Meetings

The initiation of the development of the Herring FMP was announced at the April 2016 Commission meeting in Santa Rosa, and the Herring FMP Project Management Consultant Team was introduced. Short presentations were provided at subsequent MRC meetings to inform Commissioners about the intended development process and to provide updates. In July 2016 the overall goals and timeline for Herring FMP development was presented, as well as the public notification process, which was ongoing at that time. The results of the public scoping process were shared at the March 2017 MRC meeting as well as the current intended scope of the Herring FMP. To support the development of a management strategy, a presentation providing an overview of the analyses underway was given at the July 2017 MRC meeting. During the March 2018 MRC meeting a more in-depth presentation was given to describe the core pieces of the proposed management strategy, including development of a HCR that accounts for ecosystem needs and a collaborative research protocol. During the July 2018 MRC meeting a presentation was given to describe conducting an external peer review and updates to the HCR framework, collaborative research, regulations and permitting, and timeline. During the March 2019 MRC meeting a presentation was given to provide an update on the commercial herring fishery catch and participation over time, and Herring FMP updates including peer review recommendations and the agreed HCR framework.

The Herring FMP and proposed recreational and commercial regulations were discussed at the following MRC and Commission meetings (2016-2019). At each of these meetings members of the public were given the opportunity to ask questions and/or provide comments.

1. April 13, 2016 Commission meeting
2. July 21, 2016 MRC meeting
3. March 23, 2017 MRC meeting
4. July 21, 2017 MRC meeting
5. March 6, 2018 MRC meeting
6. July 17, 2018 MRC meeting
7. March 20, 2019 MRC meeting

Public Meetings and Opportunities for Public Comment
Throughout the Herring FMP development process, the public has been able to submit questions or comments to Department staff via email or by phone. In addition, a public meeting was held in Sausalito in April 2016 to announce the initiation of the Herring FMP and to allow the public to ask questions. Once a management strategy was developed and agreed upon by the SC, that strategy was presented at a public meeting in Sausalito in January 2018. The meeting was filmed and posted online.

Notice of Preparation and Scoping Meeting for CEQA Process
On August 25, 2018, the Department held a meeting to alert the public they had prepared an Initial Study, detailed project description, and a preliminary analysis of the environmental impacts pursuant to CEQA. The meeting was publicized using the Herring FMP email list, on the Herring Management blog, and on the Department’s Marine Region website. The meeting provided an opportunity for people to ask questions and provide feedback on what environmental impacts they were most concerned about. The public was also allowed to submit comments by email or mail from August 17 to September 21, 2018.

IV. Description of Reasonable Alternatives to Regulatory Action

(a) Alternatives to Regulation Change:

During the development of the Herring FMP a number of alternatives to the individual changes presented in the Herring FMP were considered. The discussion of alternatives in this document will focus primarily on feasible management actions that could be modified to either improve the economics of the participants in the fishery or reduce environmental effects by increasing the HCR. However, these alternatives were considered during the Herring FMP development and were found to be less effective at jointly meeting both environmental and economic goals and objectives for this fishery. Based on the available science as well as feedback from environmental and industry stakeholders and the general public, the Department recommends the management approach detailed in the Herring FMP and the corresponding regulatory changes described in Section III of this document.

1. A recreational bag limit of 100 pounds

In soliciting public comment on the proposed management strategy in the Herring FMP, many recreational participants responded that a 50-pound daily bag limit (about one 5-gallon bucket, or approximately 260 fish) was sufficient to meet their needs. However, there were some recreational participants who felt that this amount of catch was too limiting because there are so few spawns during the year that are accessible by recreational participants. Some participants commented that they share herring with family members and would like to see a higher bag limit of 100 pounds (two 5-gallon buckets, or approximately 400 fish) to facilitate this. While it is true that not all spawning events are accessible to recreational fishermen, those that are vulnerable to recreational take typically experience very intense fishing pressure, with reports of hundreds of fishermen lined up shoulder to shoulder on piers and jetties and in the intertidal zone, fishing with hook and line or cast nets. Thus, the recreational fishing pressure on some spawning events may be significant. It is the Department's goal to protect the sustainability of the resource while maintaining a satisfying recreational experience and based on feedback this can likely be achieved with a bag limit of 50 pounds or 5 gallons.

2. A HCR with a 25,000 ton cut-off for San Francisco Bay

Under this alternative, the HCR for San Francisco Bay would be structured to have a cutoff at 25,000 tons versus the 15,000 tons in the HCR that the SC came to consensus on and recommended. Under this HCR, in years where the SSB was estimated to be below the 25,000 ton cutoff, no fishing would occur and the quota for the coming season would be zero. Above the 25,000 ton cutoff, the harvest rate would ramp up from 5% to 10% until the SSB reaches 40,000 ton. After that point, the quota would be capped at 4,000 tons.

The HCR with a higher cutoff threshold was designed to provide a more conservative approach to managing the fishery and ensure that more herring would be available to predators within the California Current Ecosystem during low biomass years. However, based on analysis of HCR performance using Management Strategy Evaluation (MSE), the higher cutoff resulted in only marginal improvements in the projected SSB in the long term, with considerable decreases in average catch and increases in the probability of zero quota years. One of the key performance metrics considered in the MSE simulations was the probability of being above a critical low biomass threshold (defined as 10% of unfished biomass) in the last 10 years of a 50-year simulation. The recommended HCR with a 15,000 ton cutoff had a 96% probability of the stock size being above this critical threshold, while a 25,000 ton cutoff only increased that probability by 1%. Additionally, the HCR with a 25,000 ton cutoff had only a slightly higher probability of reaching the target biomass than the agreed upon HCR (64% vs 60%). In summary, while the HCR with a 25,000 ton cutoff is designed to provide more forage for predators in years with low biomass, it only minimally improves the long term size of the herring SSB.

The HCR with a 25,000 ton cutoff also had significant negative impacts on economic performance metrics. This HCR had an average catch that was 30% lower than the recommended HCR and the highest variability in catch of any HCR analyzed, and was projected to cause fishery closures 38% of the time. As a result, the relatively modest gains in terms of meeting the stock size objectives were deemed to come at too high of an economic cost by the SC, and the consensus was that the recommended HCR should be used to set quotas.

3. Alternative fishing gear.

This alternative would allow additional fishing gear to be permitted for the commercial sector besides gill net gear with the prescribed mesh size. Round haul gear, which is a type of purse seine, was previously used in the fishery until 1994, when the Commission adopted regulations stating that all round haul permittees had five years to convert their permit to a gill net permit. At the time, the rationale behind this change was that round haul gear caught smaller, younger, lower value fish, and it was suspected that seiners increased mortality in the fishery by catching and releasing herring during roe percentage testing (attachment 1; Appendix K for a full history of the round haul conversion process). Seine nets are also more efficient than the gill net gear and can take considerably more fish in a shorter time period. This can mean that herring schools that spawn early in the season make up a disproportionate amount of the catch each year, and thus may contribute less spawning each year.

During the public scoping and public comment periods of the Herring FMP, the Herring FMP Project Management Consultant Team received a few requests to consider allowing the use of alternative gear types to take herring. In addition to one comment asking the Department to re-allow purse seine gear, there were other requests to consider other types of gear with smaller mesh than the currently used gill nets, including lampara gear and cast nets. The Department and the SC considered the pros and cons of these various options. It was decided that a return to round haul gear would not be considered due to the concerns listed above. However, lampara and cast net gear types were discussed because stakeholders have expressed an interest in facilitating a fresh fish fishery for a local market, and feel these gears would allow for smaller catches of higher quality fish necessary to fulfill fresh fish market orders, which could evolve into a lucrative market for herring.

However, any consideration of new gear types needs to examine the potential impact of smaller sized mesh on the health of the resource. One of the management objectives outlined in the Herring FMP is that all herring are able to spawn at least once prior to becoming vulnerable to the fishery. Herring mature between their second and third year, and the current restrictions on gill net mesh sizes have resulted in the consistent take of herring that are primarily four years of age and older (attachment 1; Section 7.8.3 of the Herring FMP). Any allowance of new gear types would need to carefully consider the age of herring targeted by that gear and whether it is compatible with the management objectives for this fishery. It is important to note that it is possible to take herring of a quality compatible with the fresh fish market by using the currently approved gill net gear with different handling practices.

(b) No Change Alternative:

Under the “No Change” alternative, the Herring FMP implementing regulations and proposed commercial and recreational regulatory changes would not be adopted. Instead, the fishery would continue to be managed without a comprehensive management plan under current regulations. This alternative does nothing to promote a comprehensive management plan for the herring fisheries and does not bring herring management into conformance with the MLMA through adoption of implementing regulations as directed by the Legislature. While this alternative is not expected to result in immediate adverse impacts to the herring resource and fisheries, due to the generally conservative nature of current regulations (e.g. quotas, gear restrictions, temporal and spatial restrictions, etc.), it would forego the greater opportunity for sustainable management under a comprehensive FMP as required by the MLMA. The proposed commercial and recreational changes will clarify and improve enforcement of existing regulations and provide for a more orderly fishery.

(c) Description of Reasonable Alternatives That Would Lessen Adverse Impact on Small Business:

Most commercial herring industry participants are small businesses (as defined under California Government Code Section 11342.610). In view of information currently possessed, no reasonable alternative considered would be more effective in carrying out the purpose for which the regulation is proposed, would be as effective and less burdensome to affected private persons than the proposed regulation, or would be more cost effective to affected private persons and equally effective in implementing the statutory policy or other provision of law.

V. Mitigation Measures Required by Regulatory Action

The proposed regulatory action will have no negative impact on the environment; therefore, no mitigation measures are needed.

VI. Impact of Regulatory Action

The potential for significant statewide adverse economic impacts that might result from the proposed regulatory action has been assessed, and the following initial determinations relative to the required statutory categories have been made:

(a) Significant Statewide Adverse Economic Impact Directly Affecting Businesses, Including the Ability of California Businesses to Compete with Businesses in Other States:

The proposed action will not have a significant statewide adverse economic impact directly affecting business, including the ability of California businesses to compete with businesses in other states. Individuals and businesses will not incur any increase in compliance costs. The decrease in the fleet size may result in more profitable catch per unit effort for individuals. However, harvest volume and fishing intensity will continue to be highly influenced by market prices and many other factors unrelated to Commission regulations.

(b) Impact on the Creation or Elimination of Jobs Within the State, the Creation of New Businesses or the Elimination of Existing Businesses, or the Expansion of Businesses in California; Benefits of the Regulation to the Health and Welfare of California Residents, Worker Safety, and the State's Environment:

The proposed action is not anticipated to impact the creation or elimination of jobs, the creation of new business, the elimination of existing businesses, or the expansion of businesses in California because the proposed regulations will not impose new compliance costs or adversely impact fishing activity in the state.

The proposed action is not anticipated to benefit the health and welfare of California residents or worker safety, but benefits to the State’s environment are anticipated through the improved management of Herring resources.

(c) Cost Impacts on a Representative Private Person or Business:

The agency is not aware of any cost impacts that a representative private person or business would necessarily incur in reasonable compliance with the proposed action.

(d) Costs or Savings to State Agencies or Costs/Savings in Federal Funding to the State: None.

(e) Nondiscretionary Costs/Savings to Local Agencies: None.

(f) Programs Mandated on Local Agencies or School Districts: None.

(g) Costs Imposed on Any Local Agency or School District that is Required to be Reimbursed Under Part 7 (commencing with Section 17500) of Division 4, Government Code: None.

(h) Effect on Housing Costs: None.

VII. Economic Impact Assessment

Herring support an important and historically significant commercial fishery in California. They are also a critical food source for many predatory fish, marine mammals, and seabirds. Since the late 1990s, the number of active herring fishermen and the harvest volumes have declined substantially largely driven by declines in market demand and resource abundance. The goal of the Herring FMP is to formalize a management strategy that is responsive to environmental and socioeconomic changes and establishes a decision-making process that preserves the sustainability of the fishery while considering the entire ecosystem. The proposed regulatory actions are intended to further those goals effectively with the little to no interruption to the herring fishery and associated businesses.

Subsection (a)(6)(E) establishes a small Processing (Drawing) Fee for participating in a Department drawing for available new permits. The calculation of the proposed fee is shown below.

Item Fee Calculation & Cost Recovery Sheet for			
Herring Permit Drawing Application			
Number of expected items sold per year:	122		
Start up Costs			
Cost Description	**Hours**	**Rate**	**Total**
ALDS IT support: Item setup/ configuration /reporting			
Information Technology Specialist I	4	$ 68.00	$ 272.00
Program review or Item Setup and configuration (AGPA)	4	$ 52.32	$ 209.28
Total Startup Costs			**$ 481.28**
Amortized over 5 years:			**$ 96.26**
Ongoing Costs			
Cost Description	**Hours**	**Rate**	**Total**
ALDS IT support: Item Review			
Information Technology Specialist I	1	$ 68.00	$ 68.00
Program Staff Item review (AGPA)	2	$ 50.96	$ 101.92
Ongoing Costs Total			**$ 169.92**
Amortized startup costs (from Above)			**$ 96.26**
Overhead	**24%**		**$ 64.73**
Item Total Annual Startup and Ongoing Costs			**$ 330.91**
Item Startup and ongoing cost per transaction			**$ 2.71**
Item Fee Calculation			
Item Startup and ongoing cost per transaction			$ 2.71
ALDS System costs Per transaction			$ 0.78
LRB Operations costs Per transaction			$ 0.89
Item Fee			**$ 4.38**
Item Fee (rounded to nearest .25) per FGC Section 713			**$ 4.50**
License Buyer Surcharge	**3%**		**$ 0.14**
Total for Customer:			**$ 4.64**

(a) Effects of the Regulation on the Creation or Elimination of Jobs Within the State:

None. Business activity is spurred more by herring and herring roe prices that are set on the international market and not directly impacted by California regulations and quotas.

(b) Effects of the Regulation on the Creation of New Businesses or the Elimination of Existing Businesses Within the State:

None. Business activity is spurred more by herring and herring roe prices that are set on the international market and not directly impacted by California regulations and quotas.

(c) Effects of the Regulation on the Expansion of Businesses Currently Doing Business Within the State:

None. Business activity is spurred more by herring and herring roe prices that are set on the international market and not directly impacted by California regulations and quotas.

(d) Benefits of the Regulation to the Health and Welfare of California Residents: None.

(e) Benefits of the Regulation to Worker Safety: None.

(f) Benefits of the Regulation to the State's Environment:

The proposed regulatory action is expected to benefit the environment by supporting a more sustainable herring fishery that will benefit individuals, businesses, and other species dependent upon healthy herring resources.

(g) Other Benefits of the Regulation:

The proposed changes to the regulations support the Marine Life Management Act (MLMA) [MLMA, Statutes 1999 Chapter 483], which declares that "conservation and management programs prevent overfishing, rebuild depressed stocks, ensure conservation, facilitate long term protection and, where feasible, restore marine fishery habitats".

Informative Digest/Policy Statement Overview

The purpose of these proposed amendments to regulations is the implementation of the *California Pacific Herring Fishery Management Plan* (Herring FMP). This Fishery Management Plan (FMP) has been produced pursuant to the Marine Life Management Act (MLMA). The amendments are further necessary to improve management of the existing commercial and recreational Pacific Herring fisheries and to support the orderly use of this natural resource.

Regulations pertaining to California's herring fisheries are currently in multiple sections of Title 14 of the California Code of Regulations (CCR). Section 163 regulates the commercial harvest of herring. Section 163.1 regulates the transfer of herring permits. Section 163.5 stipulates penalties and Section 164 regulates the harvesting of herring eggs. The recreational fishery is not regulated.

It is the policy of the State to ensure the conservation, sustainable use, and, where feasible, restoration of California's marine living resources for the benefit of all the citizens of the State (Fish and Game Code (FGC) Section 7050(b)). To achieve this goal, the MLMA of 1999 (FGC sections 7050-7090) contemplates the use of FMPs developed by the Department of Fish and Wildlife (Department) and adopted by the Fish and Game Commission (Commission) (FGC sections 7072, 7075 and 7078) to guide fishery management. FGC subsection 7071(b) also provides authority for the Commission to adopt regulations that implement an FMP or plan amendment.

In accordance with these provisions, the Department has developed a Draft Herring FMP to ensure the long-term sustainability of the resource and the fisheries that rely on it. The Herring FMP includes a proposed overhaul of the limited entry permit system, a Harvest Control Rule (HCR) for the San Francisco Bay fishery, a tiered management framework for setting quotas in all areas, collaborative research protocols, and a proposed daily bag limit for the recreational fishery. Along with the Herring FMP, the Department has also prepared proposed implementing regulations that create new recreational restrictions and deletes or amends existing commercial requirements.

The proposed regulations are divided into four parts: 1) new recreational fishing regulations, 2) regulations to implement the Herring FMP, 3) amendments and additions to the commercial fishing regulations, and 4) provision of forms and fees. The following is a summary of the proposed changes to Title 14, CCR:

1. Add new recreational herring regulations to Section 28.62, Title 14, CCR, and amend existing regulations in sections 27.60 and 28.60, Title 14, CCR. The proposed regulations will:
    - Establish a bag limit within the range of zero to ten (0-10) gallons, which is approximately 0 to 100 pounds, or 0-520 fish. The Department is recommending a daily bag limit of five (5) gallons.
    - Remove "Pacific Herring" from the list of species with no recreational bag limit.
    - Clarify the species (Pacific Herring) in the existing bag limit on recreational take of herring eggs on kelp.

2. Add Article 6 of Chapter 5.5 of Subdivision 1 of Title 14, CCR; California Pacific Herring Fishery Management Plan, and add new Sections 55.00, 55.01, and 55.02. The proposed new sections will:
    - Describe the purpose and scope of the Herring FMP;
    - Provide relevant definitions used in the Herring FMP;
    - Describe the management process and HCR.

3. Delete and redraft all existing commercial regulatory language and associated subsections in sections 163, 163.1, 163.5, and 164 Title 14, CCR.
   - The new language in Section 163 includes all regulations related to permits (both herring and herring eggs on kelp (HEOK)), including permit transfers and revocation conditions.
     - A continued requirement that herring or HEOK taken in excess of the quota be released to the Department using the Release of Property Form FG-MR 674.
   - The new language in Section 163.1 describes methods of commercial take for herring, and
   - Section 163.5 provides regulations for the Herring Buyer's Permit.
   - Section 164 is amended regarding the landing of HEOK, with a new requirement that anyone receiving HEOK must have a Herring Buyer's Permit.
     - The royalty fee of $500 per ton of herring eggs on kelp will no longer be required.
     - The Herring-Eggs-on-Kelp Monthly Landings and Royalty Report (DFW 143 HR (REV. 06/04/15), will be repealed and no longer required.
     - Authorized Agent form MRD 164 is repealed, however, agents may be designated on form 1406 Herring Eggs on Kelp Application.

4. Amend Section 705 Commercial Fishing Applications, Permits, Tags, and Fees. Because of the adoption of the Herring FMP, and the adoption of the amendments to the herring fishery regulations as described herein, it is necessary to amend the forms, provide fees to recover reasonable Department costs, and to make the forms consistent with current regulations. The following forms, to be Incorporated by Reference, are attached to the Regulatory Text:
   - DFW 327 (New 4/11/19) 2019-2020 HERRING BUYER'S PERMIT APPLICATION
   - FG-329 Herring Fresh Fish Market Permit is deleted
   - DFW 1406 (New 4/11/19) HERRING-EGGS-ON-KELP PERMIT APPLICATION
   - DFW 1322-2 (New 4/11/19) SEASON REQUEST FOR CHANGES TO HERRING PERMITS: BOAT TRANSFER & SIMULTANEOUS FISHING
   - DFW 1377 (New 4/11/19) COMMERCIAL HERRING PERMIT WORKSHEET
     - A new drawing fee of $4.50 for Applications for New Herring Permits

These proposed regulations were drafted to achieve the sustainability and social policy objectives enumerated in FGC sections 7050, 7055, and 7056. The amended sections would not conflict with any existing Title 14 regulations. In accordance with FGC Section 7071(b), the implementing regulations of this Herring FMP will render the following sections of the FGC inoperative once they are adopted: FGC sections 8389, 8550, 8550.5, 8552, 8552.2, 8552.3, 8552.4, 8552.5, 8552.6, 8552.7, 8552.8, 8553, 8554, 8556, 8557, 8558, 8558.1, 8558.2, 8558.3, and 8559.

Benefit of the Regulations

It is the policy of the State to ensure the conservation, sustainable use, and, where feasible, restoration of California's marine living resources for the benefit of all the citizens of the State. To achieve this goal, the MLMA contemplates the use of FMPs developed by the Department and adopted by the Commission to guide fishery management. The Commission may adopt regulations that implement the FMP.

Consistency with State Regulations

The Commission and Department have conducted a review of the California Code of Regulations and determined that the proposed regulations are neither inconsistent nor incompatible with existing State regulations. No other State agency has the statutory authority to amend regulations pertaining to the herring fishery.

Proposed Regulatory Language

Subsection (b) of Section 27.60, Title 14, CCR, is amended to read**:**

§ 27.60. Limit.

. . . [No change to subsection (a)]

(b) There is no limit on the following species: anchovy, grunion, jacksmelt, topsmelt, Pacific butterfish (pompano), queenfish, sanddabs, skipjack, jack mackerel, Pacific mackerel, Pacific staghorn sculpin, round herring, ~~Pacific herring,~~ Pacific sardine, petrale sole and starry flounder.

. . . [No change to subsection (c)]

Note: Authority cited: Sections 200, ~~202,~~ 205, 265, 7071 and 8587.1, Fish and Game Code.
Reference: Sections 205, ~~210,~~255, 7071, ~~and~~ 7120~~,~~ and 8587.1, Fish and Game Code.

Proposed Regulatory Language

Section 28.60, Title 14, CCR, is amended to read:

§ 28.60. Pacific Herring Eggs.

Limit: Twenty-five pounds (including plants) wet weight of Pacific Herring eggs may be taken per day for recreational purposes.

Note: Authority cited: Sections 200, ~~202,~~ 205, ~~210,~~ 219, 255, 265 and 275, ~~and 220~~, Fish and Game Code. Reference: Sections 200~~-202~~, 203.1, ~~205-210 and 215-222,~~ 205, 219, 255, 265 and 270, Fish and Game

Proposed Regulatory Language

Section 28.62 was repealed in 1988, the remaining text in Title 14 is hereby deleted:

~~§ 28.62. Herring. [Repealed]~~

~~Note: Authority cited: Sections 200, 202, 205, 210, 219 and 220, Fish and Game Code. Reference: Sections 200-202, 203.1, 205-210 and 215-222, Fish and Game Code.~~

Section 28.62, Title 14, CCR, is added to read:

§ 28.62. Pacific Herring Bag Limit.

Limit: [Zero–Ten (0 - 10)] gallons of Pacific Herring may be taken per day for recreational purposes.

Note: Authority cited: Sections 200, 205, 219, 255, 265 and 275, Fish and Game Code.
Reference: Sections 200, 205, 219, 255, 265 and 270, Fish and Game Code

Proposed Regulatory Language

Article 6 of Chapter 5.5, Title 14, California Code of Regulations, is added to read:

Article 6. California Pacific Herring Fishery Management Plan

Section 55.00, Title 14, CCR, is added to read:

§ 55.00 Purpose and Scope

(a) This Article implements the California Pacific Herring Fishery Management Plan (Herring FMP) as adopted and amended by the Fish and Game Commission (commission), consistent with the requirements of Part 1.7, Conservation and Management of Marine Living Resources, commencing with Section 7050 of the Fish and Game Code, as further set forth in the Marine Life Management Act of 1999. These regulations, in combination with other applicable provisions of the Fish and Game Code and Title 14, CCR, govern management and regulation of the herring resources and fisheries.

(b) Regulations implementing the Herring FMP specific to the recreational take of herring are found in sections 28.60 and 28.62; regulations specific to the commercial take of herring are found in sections 163, 163.1, 163.5 and 164.

(c) Pursuant to Fish and Game Code Section 7071(b), Article 15, Sections 8389, 8550, 8550.5, 8552, 8552.2, 8552.3, 8552.4 8552.5, 8552.6, 8552.7, 8552.8, 8553, 8554, 8556, 8557, 8558, 8558.1, 8558.2, 8558.3 and 8559, Fish and Game Code, are made inoperative.

Note: Authority cited: 7071 and 7078, Fish and Game Code. Reference: Part 1.7 and Article 15, Fish and Game Code.

Proposed Regulatory Language

Section 55.01, Title 14, , is added to read:

§ 55.01 Definitions

(a) “Herring” means Pacific Herring, *Clupea pallasii*.

(b) “Herring FMP” means the *California Pacific Herring Fishery Management Plan* as adopted by the Fish and Game Commission on October 10, 2019.

(c) “Herring Management Strategy” means ‘*Chapter 7 Management Strategy for California Herring’* of the Herring FMP, as adopted by the commission.

(d) “Quota” means a specified numerical maximum catch (in weight) for each fishing season and sector, the attainment (or expected attainment) of which may cause closure of the fishery.

(e) “Catch” means the total weight of herring reported on commercial landing receipts in a fishing season.

Note: Authority cited: 7071 and 7078, Fish and Game Code. Reference: 7071, 7075 and 7082, Fish and Game Code.

Proposed Regulatory Language

Section 55.02, Title 14, CCR, is added to read:

§ 55.02 Management Strategy

(a) The *California Pacific Herring Fishery Management Plan* adopted by the commission on October 10, 2019, is incorporated by reference herein and has the effect of regulation in Title 14, CCR.

(b) The Herring Management Strategy will conform to the goals, objectives, criteria, procedures, and guidelines of Chapter 7 of the Herring FMP, and other applicable state and federal laws and regulations.

(c) Annual monitoring and assessment of the herring fishery will be conducted as directed by the Herring Management Strategy, Chapter 7 of the Herring FMP.

(d) The director shall have the authority to set the annual quotas for all areas and fishery sectors, including herring and herring eggs on kelp commercial sectors, using the approach identified in the Herring Management Strategy, Chapter 7 of the Herring FMP.

(e) Other conservation and management measures may be developed, considered, and implemented to achieve management plan goals and objectives at the discretion of the commission.

Note: Authority cited: Sections 7071 and 7078, Fish and Game Code. Reference: 7050, 7055, 7056, 7070, 7071 and 7075, Fish and Game Code.

Proposed Regulatory Language

Section 163, Title 14, CCR, is **amended** to read:

§ 163. ~~Harvest of~~ **Pacific Herring Permits.**

~~Herring may be taken for commercial purposes only in those areas and by those methods specified in subsections (f)(1) and (f)(2) of this section under a revocable permit issued to an individual on a specified fishing vessel by the department. Transfer of permits from one boat to another may be authorized by the department upon application by the permittee. The fee for any approved transfer or substitution of a permit pursuant to this paragraph shall be the fee specified in Section 705, Title 14, CCR, for any request received by the department after November 15, and must be submitted with the transfer or substitution on the form specified in Section 705, Title 14, CCR, to the department's License and Revenue Branch office. Any permittee denied a transfer pursuant to this paragraph may request a hearing before the commission to show cause why his or her request should not be denied. Permittees shall have their permit(s) in their possession (including the attachment of any changes approved by the department after the permit is issued) and shall be aboard the vessel named on their permit(s) at all times during herring fishing operations, except that the department may authorize a permittee to have a crew member temporarily serve in his or her place aboard the vessel during a season. Applications for temporary permittee substitution must be submitted by the permittee. Two permits may be jointly fished on a single vessel upon approval of a written request by both permittees to the department. In San Francisco Bay a permittee may simultaneously fish his or her own "DH" permit with his or her own respective odd or even permit. A permittee may simultaneously fish his or her own permit and a permit temporarily transferred to him or her on a single vessel within the same fishing group. A permittee serving as a temporary substitute on a permit while simultaneously fishing his or her own permit on a single vessel in the same fishing group shall incur the same penalties on his/her permit for all violations as those incurred against the permit for which he/she is serving as temporary substitute as prescribed in these regulations and in Section 163.5, Title 14, CCR. A person may not serve as a temporary substitute on more than one permit simultaneously on a single vessel in the same fishing group. Any request received by the department from November 1 to November 15 to transfer boats or substitute a permit or to simultaneously fish two permits on a single vessel shall be processed for approval by the department after November 15.~~

~~(a) Qualifications of Permittee. To obtain a permit to take herring a person shall:~~

~~(1) Be a currently licensed California commercial fisherman. When a permit is held in partnership (pursuant to the provisions of Section 8552.6 of the Fish and Game Code), both partners must be currently licensed California commercial fishermen.~~

~~(2) Have been a permittee during the previous herring season.~~

~~(3) Qualify for an odd- or even-numbered permit as specified in subsection (c)(1)(B).~~

~~(4) Qualify for a "DH" gill net permit as specified in subsection (c)(1)(C).~~

~~(5) Have submitted a release of property forms and payment for all herring landed in excess of the established quota as specified in subsection (e)(5) of these regulations, and all fees from prior seasons.~~

~~(6) Any person denied a permit under these regulations may request a hearing before the commission to show cause why his or her permit should not be denied.~~

~~(b) Permit Applications. Each applicant for a herring permit shall:~~

~~(1) Submit the completed application as specified in Section 705, Title 14, CCR, to the address listed on the application. Applications shall include the fee, as specified in section 8550.5 of the Fish and Game Code.~~

~~(2) Permittees will be issued permits for the same area and gear type they held during the previous season. In San Francisco Bay, round haul permittees who transferred gear type to gill net were designated as CH-(600-642)-SF permittees. For every conversion of gear type to gill net by a round haul permittee, the amount of herring allocated to each round haul permittee was transferred from the round haul quota to the gill net quota. For each round haul permit converted prior to October 6, 1995, fishing with gill net gear is authorized in two of the following fishing periods: odd-numbered permits, even-numbered permits, or December herring ("DH") permits. The permitholder of a converted round haul ("CH") permit is permanently assigned to the two fishing groups ("DH", odd-, or even-numbered permit) he or she designated. For every conversion of gear type to gill net by a round haul permittee after October 6, 1995 but before October 2, 1998, the permit is permanently in the two fishing groups ("DH", odd-, or even-numbered permit) assigned by the department. All remaining round haul permits as of October 3, 1998 were converted to gill net permits and assigned to a single gill net group.~~

~~Upon transfer, the department assigned each converted "CH" permit to a single gill net group ("DH", odd numbered, or even-numbered permit) as designated by the permitholder. A round haul herring permit, held in partnership prior to November 3, 1994 and subsequently converted to a "CH" permit prior to October 2, 1998, is not subject to assignment to a single gill net group upon transfer to one of the partners.~~

~~(3) Permit Renewal. Applications for renewal of all herring permits shall be received by the department, or if mailed, postmarked, on or before the first Friday of October each year. Late fees, late fee deadlines, and late renewal appeal provisions are specified in Fish and Game Code Section 7852.2.~~

~~(4) Subsections (a)(2) and (b) do not apply to permits issued for taking herring in ocean waters.~~

~~(c) Permits.~~

~~(1) Permits to take herring for commercial purposes will be issued by the department beginning November 15. Permits will be sent by first class mail to the permittees. Not more than three permits shall be issued for Crescent City and not more than four permits shall be issued for Humboldt Bay. No new round haul permits shall be issued for San Francisco Bay. No new gill net permits shall be issued for the Tomales Bay permit area until the maximum number of permits is less than 35. No new odd- or even-numbered gill net permits shall be issued for San Francisco Bay until the maximum number of permits is less than 160. No new "DH" permits shall be issued until the maximum number of permits is less than 80. The permittee shall be responsible for all crew members acting under his or her direction or control to assure compliance with all commission regulations as provided in this section, or in the Fish and Game Code, relating to herring.~~

~~(A) The total number of gill net permits issued to individuals not qualifying under subsection (a)(2) shall be the difference in number of permittees meeting such qualifications and the total number of gill net permits authorized by the commission in subsection (c)(1).~~

~~(B) Individuals not qualifying under subsection (a)(2) will be eligible to apply for any available odd- or even-numbered gill net permits provided they are a currently licensed California commercial fisherman.~~

~~(C) Individuals not qualifying and receiving permits under subsections (a)(2) or (c)(1)(B) will be eligible to apply for any available "DH" gill net permits provided they are a currently licensed California commercial fisherman.~~

~~(D) In the event that the number of eligible applicants qualifying under subsections (c)(1)(B) or (c)(1)(C) exceeds the available permits, a lottery shall be held.~~

~~(E) Preferential status will not be given for participation on vessels with permits specified in subsection (c)(2) of this section.~~

~~(2) Ocean Waters. No permits shall be issued.~~
~~(d) Vessel Identification. The master of any boat engaged in taking herring under these regulations shall at all times while operating such boat, identify it by displaying on an exposed part of the superstructure, amidship, on each side of the house and visible from the air, the herring permit number of that vessel in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background permanently fixed to each side of the vessel.~~
~~(e) Monitoring of Herring.~~
~~(1) Any herring taken for commercial purposes shall only be delivered to a person licensed pursuant to subsection (j) of these regulations.~~
~~(2) Gill net permittees shall notify the department's Santa Rosa Marine Region office within 24 hours if they terminate fishing operations for the season prior to the overall quota being taken.~~
~~(3) The department will estimate from the current trend of individual boat catches the time at which the herring season catch will reach any quota permitted under these regulations and will publicly announce that time on VHF/Channel 16. It shall be the responsibility of all permittees to monitor this radio channel at all times. Any announcement made by the department on VHF/Channel 16 shall constitute official notice. All fishing gear must be removed from the water by the announced time terminating fishing operations. The department may announce a temporary closure for the gill net fishery in order to get an accurate tally of landings and to allow all boats to unload. If the fishery is reopened, permittees may be placed on allotted tonnages to preclude exceeding a quota and, if necessary, additional time may be granted to reach the quotas.~~
~~(4) It is unlawful to transfer herring or herring nets from one permittee to another or from one boat to another or from one gear type to another, except that nonmotorized lighters may be used, provided they do not carry aboard any gear capable of taking herring, including net reels, and that the catches of not more than one permittee are aboard the lighters at any time. Permit vessels shall not serve as lighters for other permit boats. In San Francisco Bay a permittee and his/her gear must stay together when delivering fish to market. Except as specified in subsection (e)(6) of these regulations, all fish taken by gill nets shall be retained and landed. Gill net permit vessels may not be used to assist in herring fishing operations during their off-week.~~
~~(5) All herring landed in excess of any established permit quota shall be forfeited to the department by the signing of a Release of Property form (FG-MR-674 (Rev. 5/13)), which is incorporated by reference herein. Such fish shall be sold or disposed of in a manner determined by the department. The proceeds from all such sales shall be paid into the Fish and Game Preservation Fund.~~
~~(6) Sturgeon, halibut, salmon, steelhead and striped bass may not be taken by or possessed on any vessel operating under the authority of these regulations. All sturgeon, halibut, salmon, steelhead and striped bass shall be returned immediately to the water.~~
~~(f) Methods of Take.~~
~~(1) For purposes of this section regarding harvest of herring: San Francisco Bay is defined as the waters of Fish and Wildlife districts 12 and 13 and that portion of district 11 lying south of a direct line extending westerly from Peninsula Point, the most southerly extremity of Belvedere Island (37 degrees, 51 minutes, 43 seconds N, 122 degrees, 27 minutes, 28 seconds W), to the easternmost point of the Sausalito ferry dock (37 degrees, 51 minutes, 30 seconds N, 122 degrees, 28 minutes, 40 seconds W); Tomales Bay is defined as the waters of district 10 lying south of a line drawn west, 252 degrees magnetic, from the western tip of Tom's Point (38 degrees, 12 minutes, 53 seconds N, 122 degrees, 57 minutes, 11 seconds W) to the opposite shore (38 degrees, 12 minutes, 44 seconds N, 122 degrees, 57 minutes, 42 seconds W); ocean waters are limited to the waters of districts 6 (excluding the Crescent City area), 7, 10 (excluding Tomales Bay), 16 and 17 (except as specified in~~

subsection (h)(6) of these regulations); Humboldt Bay is defined as the waters of districts 8 and 9; Crescent City area is defined as Crescent City Harbor and that area of the waters of district 6 less than 20 fathoms in depth between two nautical measure lines drawn due east and west true from Point Saint George (41 degrees, 47 minutes, 07 seconds N, 124 degrees, 15 minutes, 16 seconds W) and Sister Rocks (41 degrees, 39 minutes, 31 seconds N, 124 degrees, 08 minutes, 43 seconds W).

(2) The use of round haul nets to take herring is prohibited.

(A) No permittee shall possess or fish more than a total of 65 fathoms (1 shackle) of gill net, as measured at the cork line, in San Francisco and Tomales bays. Said gill nets shall not exceed 120 meshes in depth. In Humboldt Bay and Crescent City Harbor, no permittee shall possess or fish in combination more than 150 fathoms of gill net.

Set gill nets shall be anchored by not less than 35 pounds of weight at each end, including chain; however, at least one-half of the weight must be anchor. Gill nets shall be tended at all times in San Francisco Bay. Tended means the registered gill net permittee shall be in the immediate proximity, not exceeding three nautical miles, of any single gill net being fished.

(B) In Tomales Bay, the length of the meshes of any gill net used or possessed in the fishery shall not be less than 2 inches or greater than 2 1/2 inches, except that four permittees (designated by the department in writing) participating in department-sponsored research on mesh size may use gill nets approved by the department with mesh less than the size designated herein. In Humboldt Bay and Crescent City Harbor the length of the meshes of any gill net used or possessed in the fishery shall not be less than 2 1/4 inches or greater than 2 1/2 inches. In San Francisco Bay the length of the meshes of any gill net used or possessed in the fishery shall not be less than 2 or greater than 2 1/2 inches, except that six permittees (designated by the department in writing) participating in department-sponsored research on mesh size may use gill nets of another size approved by the department.

Length of the mesh shall be the average length of any series of 10 consecutive meshes measured from the inside of the first knot and including the last knot when wet after use; the 10 meshes, when being measured, shall be an integral part of the net as hung and measured perpendicular to the selvages; measurements shall be made by means of a metal tape measure while 10 meshes are suspended vertically under one-pound weight, from a single stainless steel peg or nail of no more than 5/32 inch in diameter. In Humboldt Bay and Crescent City Harbor, the length of any series of 10 consecutive meshes as determined by the above specification shall not be less than 22 1/2 inches or greater than 25 inches. In Tomales Bay, the length of any series of 10 consecutive meshes as determined by the above specifications shall not be less than 20 inches or greater than 25 inches. In San Francisco Bay, the length of any series of 10 consecutive meshes as determined by the above specification shall not be less than 20 inches or greater than 25 inches.

(C) No net shall be set or operated to a point of land above lower low water or within 300 feet of the following piers and recreation areas: Berkeley Pier, Paradise Pier, San Francisco Municipal Pier between the foot of Hyde Street and Van Ness Avenue, Pier 7 (San Francisco), Candlestick Point State Recreation Area, the jetties in Horseshoe Bay, and the fishing pier at Fort Baker. No net shall be set or operated within 70 feet of the Mission Rock Pier. In the Crescent City area and Humboldt Bay gill nets may be set or operated within 300 feet of any pier.

(D) No nets shall be set or operated in Belvedere Cove north of a line drawn from the tip of Peninsula Point (37 degrees, 51 minutes, 43 seconds N, 122 degrees, 27 minutes, 28 seconds W) to the tip of Elephant Rock (southwest of Pt. Tiburon at 37 degrees, 52 minutes, 19 seconds N, 122 degrees, 27 minutes, 03 seconds W). Also, no gill nets shall be set or operated from November 15 through February 15 inside the perimeter of the area bounded as follows: beginning at the middle anchorage of the western section of the Oakland Bay Bridge (Tower C at 37 degrees, 47 minutes, 54 seconds N,

~~122 degrees, 22 minutes, 40 seconds W) and then in a direct line southeasterly to the Lash Terminal buoy #5 (G"5" buoy, flashing green 4s at 37 degrees, 44 minutes, 23 seconds N, 122 degrees, 21 minutes, 36 seconds W), and then in a direct line southeasterly to the easternmost point at Hunter's Point (Point Avisadero at 37 degrees, 43 minutes, 44 seconds N, 122 degrees, 21 minutes, 26 seconds W) and then in a direct line northeasterly to the Anchorage #9 buoy "A" (Y"A" buoy, flashing yellow 4s at 37 degrees, 44 minutes, 46 seconds N, 122 degrees, 19 minutes, 25 seconds W) and then in a direct line northwesterly to the Alameda N.A.S. entrance buoy #1 (G"1" buoy, flashing green 4s at the entrance to Alameda Carrier Channel, 37 degrees, 46 minutes, 38 seconds N, 122 degrees, 20 minutes, 27 seconds W) and then in a direct line northwesterly to the Oakland Harbor Bar Channel buoy #1 (G"1" buoy, flashing green 2.5s at 37 degrees, 48 minutes, 15 seconds N, 122 degrees, 21 minutes, 23 seconds W) and then in a direct line southwesterly to the point of beginning. (Tower C of the Oakland Bay Bridge, at 37 degrees, 47 minutes, 54 seconds N, 122 degrees, 22 minutes, 40 seconds W).~~

~~(E) No boats or nets shall be operated or set in violation of existing state regulations applying to the navigation or operation of fishing vessels in any area, including but not limited to San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor.~~

~~(F) Gill nets shall be marked at both ends with a buoy displaying above its waterline, in Roman alphabet letters and Arabic numerals at least 2 inches high, the official number of the vessel from which such net is being fished. Buoys shall be lighted at both ends using matching white or amber lights that may be seen for at least a distance of 100 yards and marked at both ends with matching flags or markers or placards, all of rigid or non-collapsible material of the same color, on a staff at least 3 feet above the water at each end, bearing the herring permit number in contrasting 4-inch black letters.~~

~~(G) The use of explosives, seal bombs, or marine mammal deterrent devices in the herring fishery is prohibited inside the waters of San Francisco Bay during the herring season.~~

~~(H) All San Francisco Bay herring permittees or their temporary substitutes shall recognize city ordinances governing transient noise sources, when fishing within 500 feet of any shoreline with residential dwellings, between the hours of 10:00 p.m. and 7:00 a.m. through implementation of noise reduction measures specified or developed by the herring fishing industry and approved by the department. Noise reduction measures include, but are not limited to: noise dampening devices for shakers and anchor chains, muffled engine exhaust systems, limited use of deck speakers, and/or reduced speed within 500 feet of shore.~~

~~(g) Quotas.~~

~~(1) Crescent City Area: The total take of herring in the Crescent City area for commercial purposes by use of gill net only shall not exceed 30 tons per season.~~

~~(2) Humboldt Bay: The total take of herring in Humboldt Bay for commercial purposes by use of gill net only shall not exceed 60 tons per season.~~

~~(3) Tomales Bay: The total take of herring for commercial purposes by use of gill net only shall not exceed 350 tons per season.~~

~~(4) San Francisco Bay: The total take of herring in San Francisco Bay for commercial purposes shall not exceed 834 tons per season. Tonnage shall be allocated on the following basis:~~

~~(A) Gill net permittees (including "CH" permittees): Tonnage shall be allocated to each fishing group (odd and even) in proportion to the number of permits that are assigned to each fishing group minus the number of permits in each platoon that are suspended for the entire season. Each gill net permittee (designated by the department in writing) participating in research sponsored by the department shall be assigned an individual quota equal to 0.5 percent of the season gill net quota per assigned platoon.~~

~~(h) Season.~~
~~(1) Humboldt Bay: The season shall be from noon on January 2 until noon on March 9.~~
~~(2) Crescent City: The season shall be from noon on January 14 until noon on March 23.~~
~~(3) San Francisco Bay: The season shall be from 5:00 p.m. on January 1, until noon on March 15. If the opening date falls on a Friday or Saturday, fishing shall commence on the first Sunday following January 1 at 5:00 p.m. If the closing date of the fishery falls on a Saturday or Sunday, fishing shall close on the Friday immediately preceding March 15 at noon.~~
~~(A) In San Francisco Bay, gill net permittees with odd numbered permits shall be permitted to fish first in odd numbered years beginning January 1 (or as specified in subsection (h)(3) of these regulations), Sunday through Friday and then alternating weeks with even numbered permits until the close of the season.~~
~~(B) In San Francisco Bay, gill net permittees with even numbered permits shall be permitted to fish first in even numbered years beginning January 1 (or as specified in subsection (h)(3) of these regulations), Sunday through Friday and then alternating weeks with odd numbered permits until the close of the season.~~
~~(C) No more than six gill net permittees (designated in writing by the department) participating in research sponsored by the department shall be permitted to fish, under the direction of the department, from 5:00 p.m. on January 1 until noon on March 15.~~
~~(4) In Tomales Bay, the season shall be from noon on December 26 until noon on February 22.~~
~~(5) Herring fishing in San Francisco Bay is not permitted from noon Friday through 5:00 p.m. Sunday night. Herring fishing is allowed in Tomales Bay from noon Friday through 5:00 p.m. Sunday night if the department is reimbursed for the cost of operations. The department shall submit a detailed invoice of its cost of operations within 30 days of providing the service. Party shall remit payment to the department within 30 days of the postmark date of the department's invoice.~~
~~(6) Ocean Waters: All fishing for herring in ocean waters will be prohibited (except as specified in subsection (f)(1) of these regulations). An incidental allowance of no more than 10 percent herring by weight of any load composed primarily of other coastal pelagic fish species or market squid may be landed.~~
~~(7) In the event permittees described under subsections (h)(3)(A) or (h)(3)(B) reach their quota pursuant to subsection (g)(4)(A), the alternate group of permittees on notification by the department may commence fishing operations until such group has reached the successive established termination date or quota.~~
~~(i) Any permit issued pursuant to this section may be suspended or revoked at any time by the commission for cause after notice and opportunity to be heard, or without a hearing upon conviction of a violation of Fish and Game Code statutes or Division 1, Title 14, CCR, while fishing as a participant in the herring fishery by a court of competent jurisdiction. A permittee whose permit has been suspended or revoked for conviction of a violation of Fish and Game Code statutes or Division 1, Title 14, CCR, while fishing as a participant in the herring fishery may request a hearing before the commission to show cause why his/her herring fishing privileges should be restored. A person whose herring permit has been revoked by the commission shall not participate in any herring fishery during the following season. A person whose herring permit has been suspended for the entire season by the commission shall not participate in any herring fishery during the season the permit is suspended. A person whose herring permit has been suspended for a period less than the entire season by the commission shall not participate in any herring fishery during the period that the permit is suspended. If a herring permit that had a temporary substitute is suspended by the commission due to the actions of the temporary substitute, the person who acted as the temporary substitute shall not participate in any herring fishery during the following season during the period that the permit is suspended. If a~~

herring permit that had a temporary substitute is revoked by the commission due to the actions of the temporary substitute, the person who acted as the temporary substitute shall not participate in any herring fishery during the following season. If a herring permittee is convicted of a violation, or if the permit is suspended or revoked, due to the actions of a temporary substitute who is simultaneously fishing his or her own permit on a single vessel in the same fishing group, the person who was acting as the temporary substitute will receive the same penalty against his/her own permit as received by the permittee, pursuant to these regulations and Section 163.5, Title 14, CCR. For Category II violations prescribed in Section 163.5(f) against a permit due to the actions of a temporary substitute while simultaneously fishing his/her own permit, equal points or penalties shall be assigned to the permit owned by the temporary substitute.

(j) Herring's Permit. A holder of a current fish receiver's license shall obtain a permit to buy herring for commercial purposes for each fishing area specified in subsection (f)(1) of these regulations and approved by the department. After approval of an application and payment of the filing fee specified in Section 705, Title 14, CCR (filing fees in Humboldt Bay and Crescent City area shall be waived), a revocable, nontransferable permit to buy herring for commercial purposes may be issued subject to the following regulations:

(1) The permittee shall permanently mark all vehicles, containers or pallets with individualized serial numbers and predetermined tare weights.

The serial number and predetermined tare weight shall be permanently marked in letters, and numerals at least 3 inches high on each side of vehicle container or pallet.

(2) A landing receipt must be made out immediately upon completion of weighing of any single boat load (hereinafter “load”) of herring of a permittee. A sample of herring for roe testing purposes shall be taken from every load. No herring shall be taken for testing purposes from a load that has not first been weighed and recorded.

(A) The landing receipt for each vessel must be completed and signed by both the herring permittee and a certified weighmaster or his/her deputy prior to commencing unloading operations of another vessel.

(B) The weighmaster or deputy filling out the landing receipt must include all information required by Fish and Game Code Section 8043 and shall sign the landing receipt with his/her complete signature. The weighmaster shall list on the landing receipt the number of fish in, and the weight of, each roe test for the landing reported on the receipt.

(C) All landing receipts that have not been delivered to the department must be immediately available to the department at the weigh station.

(D) A reasonable amount of herring will be made available by the herring buyer to the department, at no cost, for management purposes.

(3) Prior to weighing herring, each permittee shall have each weighing device currently certified and sealed by the County Division of Weights and Measures.

(4) Weight tally sheets shall be used when any load of fish is divided and placed into more than one container prior to the completion of the landing receipt. Weight tally sheets shall include the time unloading operations begin.

(A) The tally sheets shall be composed of four columns:

1. The serial or I.D. number of all containers in which the load is initially placed and all subsequent containers, if any, in which the load is placed until, and including for, shipment from the buyer's premises.

2. The gross weight;

3. The tare weight of the bin or containers; and

4. The net weight of fish. Net weight will include the weight of the herring taken for testing purposes.

~~(B) The work or weight tally sheets shall be retained by the permittee for one year, and must be available at all times for inspection by the department.~~
~~(C) When requested by the department, the buyer shall submit to the department a California Highway Patrol weighing certificate for any truck load designated by the department. Such certificate shall be placed in the U.S. Postal system to the department's Santa Rosa Marine Region office within twenty-four (24) hours of the truck's departure from the buyer's premises.~~
~~(5) In San Francisco Bay, herring may not be unloaded between the hours of 10:00 p.m. and 6:00 a.m., or at any time on Saturdays and Sundays, unless the permittee has notified and received prior approval from the department to conduct such activities during those hours.~~
~~(6) Every permittee shall comply with all applicable sections of the Fish and Game Code.~~
~~(7) The permittee is responsible to ensure that all provisions of the herring buyer's permit are complied with, even though the tasks may be delegated to others.~~
~~(8) The permit may be revoked upon violation of any provisions contained herein by the holder of the permit, his/her agents, servants, employees, or those acting under his/her direction or control and shall not be renewed for a period of one year from the date of revocation.~~

(a) Permit Required.

(1) Pacific Herring (herring) may be taken for commercial purposes only under a revocable permit issued by the department.

(2) Herring eggs on kelp (HEOK) may be taken for commercial purposes only under a revocable permit issued by the department.

(b) Classes of Permits

(1) San Francisco Bay. As of April 1, 2020, all Odd, Even, and December, referred to as ‘DH’, gill net permits not designated as HEOK in the 2019 permit year will be converted to Temporary permits and all converted roundhaul, referred to as ‘CH’, gill net permits not designated as HEOK in the 2019 permit year will be converted to San Francisco Bay herring permits. Herring permits issued to partnerships will be converted to individual permits on April 1, 2020. Permit partnerships must designate an individual to receive the permit by March 15, 2020, by contacting the Department ‘s License and Revenue Branch in writing.

(A) Temporary Permit. Each Temporary permit allows the permittee to fish one gill net of 65 fathoms or less in San Francisco Bay (defined in subsection 163.1(a)(1)). Permittees may hold a maximum of two Temporary permits. If a permittee holds two Temporary permits these will be automatically converted to a San Francisco Bay herring permit. Conversion to a San Francisco Bay herring permit is permanent. Subject to the terms and conditions in subsection (h), Temporary permits are transferrable prior to April 1, 2025. At that time, they become non-transferrable and non-renewable. No new Temporary permits will be issued.

(B) San Francisco Bay Herring Permit. Each San Francisco Bay herring permit allows the permittee to fish two gill nets of 65 fathoms or less each in San Francisco Bay. Permittees may hold a maximum of one San Francisco Bay herring permit. San Francisco Bay herring permits are renewable and transferrable subject to the terms and conditions in subsections (c) and (h). No San Francisco Bay herring permits will be issued to new applicants until after March 31, 2025.

(2) Tomales Bay Herring Permit. Each Tomales Bay herring permit allows the permittee to fish two gill nets of 65 fathoms or less each in Tomales Bay (defined in subsection 163.1(a)(2)). Tomales Bay herring permits are renewable and transferrable subject to the terms and conditions in subsections (c) and (h).

(3) Humboldt Bay Herring Permit. Each Humboldt Bay herring permit allows the permittee to fish in combination no more than 150 fathoms of gill net in Humboldt Bay (defined in subsection 163.1(a)(3)). Humboldt Bay herring permits are renewable and subject to the terms and conditions in subsections (c) and (h).

(4) Crescent City Herring Permit. Each Crescent City herring permit allows the permittee to fish in combination no more than 150 fathoms of gill net in Crescent City Harbor (defined in subsection 163.1(a)(4)). Crescent City herring permits are renewable and transferrable subject to the terms and conditions in subsections (c) and (h).

(5) Herring Eggs on Kelp (HEOK) Permit. As of April 1, 2020, all Odd, Even, and DH HEOK permits will be converted to HEOK permits, and all CH HEOK permits will be converted to one (1) HEOK permit and one (1) Temporary permit each. A HEOK permit allows the permittee to take HEOK subject to the terms and conditions in Section 164. Odd, Even, and December permittees with permits designated as HEOK in 2019 have until March 31, 2021 to elect to convert their HEOK permit to a Temporary gill net permit. HEOK permits are renewable and transferrable subject to the terms and conditions in subsections (c) and (h). New applicants may apply for any available HEOK permits after March 31, 2021.

(c) Permit Renewal.

(1) Each herring and HEOK permit is required to be renewed annually pursuant to Fish and Game Code Section 7858 and shall only be valid for that season.

(2) An applicant is eligible to renew a herring permit of the same classification if they meet all of the following requirements:

(A) Hold a current California commercial fishing license.

(B) Have held a valid, unrevoked herring permit in the immediately preceding permit year (April 1-March 31).

(C) Have submitted a Release of Property Form FG-MR-674 (Rev. 5/13), which is incorporated by reference herein, and payment for all herring landed in excess of the established quota as specified in subsection 163.1(j) or subsection 164(h) of these regulations, and all fees from prior seasons.

(3) Applicants for renewal will be issued the same class of permit they held during the previous season, unless they hold two Temporary permits. Applicants who hold two Temporary permits will be issued a San Francisco Bay herring permit.

(4) Number of permits issued.

(A) San Francisco Bay herring permits, Tomales Bay herring permits, Humboldt Bay herring permits, and Crescent City herring permits: No more than one permit will be issued to each applicant.

(B) HEOK permits: No more than one permit will be issued to each applicant.

(5) Herring permit renewals:

(A) Herring permits are renewed by submitting the completed form Commercial Herring Permit Worksheet DFW 1377 with the specified fee, as set forth in subsection 705(a) of these regulations.

(B) Permittees must designate a currently registered vessel on the form DFW 1377. Up to two Temporary permits or one permit of any other classification of herring permit may be assigned to a single vessel. Two Temporary permits held by different permittees may be jointly fished on a single vessel upon submission of the completed form Season Request for Changes to Herring Permits DFW 1322-2 (NEW 4/11/19) specified in subsection 705(b) to the department. No permit shall be valid for more than one vessel at a time.

(C) A change in a permit's vessel designation may be authorized by the department upon application by the permittee using form DFW 1322-2, and payment of the fee, as specified in subsection 705(b) of these regulations. The fee for any approved boat transfer pursuant to this paragraph must be submitted with the form DFW 1322-2 to the department's License and Revenue Branch, Sacramento. Any permittee denied a boat transfer pursuant to this paragraph may submit an appeal in writing to the commission within 60 days of such denial to show cause why his or her request should not be denied. The written appeal shall specifically identify the legal and factual grounds for challenging the department's action. The commission shall forward to the department a copy of all materials received from the applicant. The department shall respond in writing within 60 days of receipt of materials.

(6) HEOK permit renewals:

A) HEOK permits are renewed by submitting the form Herring-Eggs-on-Kelp Permit Application DFW 1406 with the specified fee, as set forth in subsection 705(a) of these regulations.

(B) The permittee shall receive written approval from the department before using a vessel for harvesting, processing or transporting HEOK. The permittee shall list the name and department registration number issued pursuant to Section 7881 of the Fish and Game Code of any vessel that will be used for harvesting, processing or transporting HEOK under the authority of the permit on the form DFW 1406.

(C) Each HEOK permittee may designate two authorized agents to operate under his or her permit on the application form DFW 1406. A copy of the current California commercial fishing license for each authorized agent shall be submitted with form DFW 1406. Any person designated as an authorized agent shall act as an authorized agent only after the permittee has received written approval from the department.

(D) An authorized agent:

1. May serve in the place of the permittee for all fishery activities requiring the presence or action of the permittee, including the signing of electronic fish tickets and/or dock tickets;

2. May serve as an authorized agent on up to two permits.

(E) A permittee may replace an authorized agent by submitting a new application form DFW 1406 as specified in subsection 705(a), to the department's License and Revenue Branch, Sacramento.

(7) For the 2020 license year, applications for renewal of herring permits must be received by the department or, if mailed, postmarked no later than May 31, 2020. Beginning in 2021, applications for renewal of herring permits must be received by the department or, if mailed, postmarked no later than April 30 of each year.

(8) Late fees and late fee deadlines are specified in Section 7852.2 of the Fish and Game Code.

(9) Any person denied a permit under this section may submit an appeal in writing to the commission to show cause why his/her permit request should not be denied. The written appeal shall specifically identify the legal and factual grounds for challenging the department's action. Such request must be received by the commission within 60 days of the department's denial. The commission shall forward to the department a copy of all materials received from the applicant. The department shall respond in writing within 60 days of receipt of materials.

(d) Applications for New Permits.

(1) Herring Permits

(A) No new San Francisco Bay herring permits shall be issued until the number of San Francisco Bay herring permits held is less than 30.

(B) No new Tomales Bay herring permits shall be issued until the number of Tomales Bay herring permits held is less than 15.

(C) No new Humboldt Bay herring permits shall be issued until the number of Humboldt Bay herring permits held is less than four (4).

(D) No new Crescent City herring permits shall be issued until the number of Crescent City herring permits held is less than three (3).

(2) HEOK permits

(A) No new HEOK permits shall be issued until the number of HEOK permits held is less than ten (10).

(3) Applications for new herring and HEOK permits shall be made available each year on April 15 through the department's Automated License Data System at department license sales offices, the department's Internet Sales site and at retail License Agents authorized to sell commercial fishing licenses.

(4) Application Requirements

(A) Applicants shall apply by May 31 of each year.

(B) Applicants shall pay the appropriate nonrefundable Drawing Fee as specified in Section 705(a).

(C) Applicants shall possess a Commercial Fishing License valid at the time of application.

(D) Applicants for new HEOK permits shall not currently possess an HEOK permit.

(E) Applicants for new herring permits shall not currently possess a herring permit and must specify the area for the permit they are requesting.

(F) Applicants shall not submit more than one HEOK drawing application for the same license year.

(G) Applicants shall not submit more than one herring drawing application for the same license year.

(H) Each applicant who applies shall receive a "drawing receipt" printed from the terminal or downloaded from the Internet. The receipt shall contain the customer's name and permanent identification number, and proof of entry into drawing.

(5) Permit Random Selection Process.

(A) Random selection using computer generated random numbers will be used to determine which applicants will be awarded permits and which applicants will be alternates. Successful applicants and a list of alternates shall be determined within 20 business days following the application deadline date. If the drawing is delayed due to circumstances beyond the department's control, the department shall conduct the drawing at the earliest date possible.

(B) Successful applicants will be notified as soon as practical.

(C) Successful herring permit applicants shall submit the completed form Commercial Herring Permit Worksheet DFW 1377 with the specified fee, as set forth in subsection 705(a) of these regulations by July 15.

(D) Successful HEOK Permit applicants shall submit the completed Herring-Eggs-On-Kelp Permit Application DFW 1406 with the specified fee, as set forth in Section 705(a), per the instructions on the application by July 15.

(E) Should permits still be available after that June 30, the alternate list shall be used to award any available permits.

(e) Conditions of the Permit.

(1) Herring may be taken for commercial purposes only in those areas and by those methods specified in Section 163.1 (for herring) or 164 (for HEOK) under a revocable permit issued by the department to an individual for use on a specified fishing vessel.

(2) Herring permits:

(A) A permittee may have any licensed commercial fisherman serve in his or her place on the designated vessel and engage in fishing, provided the permit is aboard the vessel named on the permit(s) at all times during herring fishing operations.

(3) HEOK permits:

(A) A department-issued copy of the permit shall be aboard each vessel engaged in fishing, harvesting, processing, or transporting HEOK under the authority of the permit.

(B) The permittee or his/her authorized agent shall be aboard any vessel that is harvesting, processing or transporting herring eggs under the authority of the permit. The permit shall list the names of all authorized agents and all vessels used for harvesting, processing or transporting herring eggs under the authority of the permit (This includes the attachment of any changes approved by the department after the permit is issued).

(f) Vessel Identification.

(1) When herring or HEOK are taken under these regulations, the vessel's commercial registration number shall be displayed on both sides of the boat. The number shall be black, at least 10 inches high, and on a white background. All permittees aboard the boat shall be mutually responsible for the proper display of the vessel's commercial registration number.

(g) Revocation of Permits.

(1) Permit holders, their agents, employees or those acting under their direction or control, shall comply with all applicable provisions of the Fish and Game Code relating to commercial fishing and any regulations adopted pursuant thereto.

(2) Any permit may be suspended, revoked, or canceled by the department upon breach or violation of any regulation pertaining to the take of herring; or violation of the terms or conditions of the permit by the holders thereof, their agents, employees, or those acting under their direction and control.

(3) The permittee shall be responsible for all vessel operators, authorized agents, or crew members acting under his or her direction or control to ensure compliance with all regulations as provided in this section, or in the Fish and Game Code, relating to herring.

(4) If a herring permit is suspended or revoked due to the actions of a vessel operator or authorized agent who also holds a herring permit, the person who was acting as the vessel operator or authorized agent will receive the same penalty against his/her own permit as received by the permittee, pursuant to these regulations, Section 163.1 and Section 164.

(5) A person whose herring permit has been revoked by the department shall not participate in any herring fishery during the season in which it was revoked and the following season. A person whose herring permit has been suspended for the entire season by the department shall not participate in any herring fishery during the season in which the permit is suspended. A person whose herring permit has been suspended for a period less than the entire season by the department shall not participate in any herring fishery sector during the period that the permit is suspended.

(6) A permittee whose permit has been suspended or revoked for conviction of a violation of Fish and Game Code statutes or Division 1, Title 14, CCR, while fishing as a participant in the herring fishery may submit an appeal in writing to the commission within 60 days of such suspension or revocation to show cause why his/her herring fishing privileges should be restored. The written appeal shall specifically identify the legal and factual grounds for challenging the department's action. The commission shall forward to the department a copy of all materials received from the applicant. The department shall respond in writing within 60 days of receipt of materials.

(h) Permit Transfers.

(1) Except as provided in this section, a permit shall not be assigned or transferred. The department may deny any transfer request submitted in accordance with this section, or may revoke an approved transfer, for violation of any relevant permit condition, section of these regulations, or Fish and Game Code.

(2) A person with a valid transferable permit that has not been suspended or revoked may transfer his/her permit to another person licensed as a California commercial fisherman. The permit holder or the estate of the deceased permit holder shall submit form DFW 1322-2, specified in Section 705(b), and the nonrefundable permit transfer fee specified, for each permit transfer. The transfer shall take effect on the date written notice of approval of the application is given to the transferee by the department. The permit shall be valid for the remainder of the permit year and may be renewed in subsequent years pursuant to this section.

(A) The permit-transfer fee shall be waived in the case of transfer of any Temporary Permit defined in Section 163(b) of these regulations.

(3) An application for a transfer of a permit shall be deferred when the current permit holder is awaiting final resolution of any pending criminal, civil and/or administrative action that could affect the status of the permit.

(4) Upon the death of a person with a valid permit, that person's estate shall immediately, temporarily relinquish the permit to the department's License and Revenue Branch, Sacramento. The estate may renew the permit as provided for in this section if needed to keep the permit valid. The estate may transfer the permit pursuant to this section no later than two (2) years from the date of death of the permit holder as listed on the death certificate.

(5) Any applicant who is denied transfer of a permit may submit an appeal in writing to the commission to show cause why his/permit transfer request should not be denied. The written appeal shall specifically identify the legal and factual grounds for challenging the department's actions. Such request must be received by the commission within 60 days of the date of the department's denial. The commission shall forward to the department a copy of all materials received from the applicant. The department shall respond in writing within 60 days of receipt of materials.

(i) Research.

(1) Notwithstanding any other portion of this section, the department may authorize the holder of a valid herring permit to collect herring during a closed season or in a closed area, subject to such restrictions regarding gear(s), date(s), location(s), time(s), size, poundage or other matters as specified by the department. Any fish and/or data collected during such activity shall be made available to the department.

(2) Upon approval, the department's marine regional manager or his or her designee shall issue a Letter of Authorization to the permittee containing all conditions of use.

Note: Authority cited: Sections 7071, 7078, 8389, and 8550, Fish and Game Code. Reference: Sections 7071, 8389, and 8550, Fish and Game Code.

Proposed Regulatory Language

Section 163.1, Title 14, CCR, is amended to read:

§ 163.1. ~~Herring Permit Transfers~~ **Harvest of Pacific Herring.**

~~(a) Definitions.~~
~~Individual means a single natural person.~~
~~Individually held means a permit that is not held by a partnership under Fish and Game Code Section 8552.6.~~
~~Permit means a valid entitlement issued pursuant to Fish and Game Code Section 8552, which has not been suspended or revoked, to take herring for roe purposes.~~
~~Fishing group means those platoons whose season is designated in Section 163(a) of these regulations.~~
~~(b) Multiple permits. In the San Francisco Bay fishery, no person may ever hold, either individually or in partnership, more than a total of three permits, and/or more than one permit in any fishing group.~~
~~(c) Notice/application to transfer and transfer fee. A transfer under this regulation does not require the notice to qualified point holders required by Fish and Game Code Section 8552.2. The permit holder must submit a notarized letter, signed by the permit holder, to the department's San Francisco Bay Area Marine Region office requesting transfer of the permit, identifying the individual to whom the permit is to be transferred. Notwithstanding Fish and Game Code Section 8552.7 the fee to transfer a herring permit is one thousand dollars ($1000). The fees shall be deposited in the Fish and Game Preservation Fund and shall be expended for research and management activities to maintain and enhance herring resources pursuant to subsection 8052(a) of the Fish and Game Code.~~
~~(d) Permit Renewal. Each permit individually held shall be separately renewed according to the procedures in Section 163 of these regulations.~~
~~(e) Appeals. Any individual who is denied the transfer of a permit may appeal in writing to the department's San Francisco Bay Area Marine Region office not more than 60 days from the date of denial. The appeal shall describe the basis for the appeal and contain all supporting evidence. If the denial is sustained, the individual may appeal in writing to the commission within 60 days of the date of the department's decision.~~

(a) Areas. Pacific Herring (herring) may be taken for commercial purposes only in the following areas:

(1) San Francisco Bay. San Francisco Bay is defined as the waters of Fish and Wildlife Districts (District) 11, 12 and 13.

(A) No net shall be set or operated to a point of land above mean lower low water or within 300 feet of the following piers and recreation areas: Berkeley Pier, Paradise Pier, San Francisco Municipal Pier between the foot of Hyde Street and Van Ness Avenue, Pier 7 (San Francisco), Candlestick Point State Recreation Area, the jetties in Horseshoe Bay, and the fishing pier at Fort Baker. No net shall be set or operated within 70 feet of the Mission Rock Pier.

(B) No nets shall be set or operated in the following areas:

1. Belvedere Cove north of a line drawn from the tip of Peninsula Point (37° 51' 43" N, 122° 27' 28" W) to the tip of Elephant Rock (southwest of Pt. Tiburon at 37° 52' 19" N, 122° 27' 03" W).

2. No gill nets shall be set or operated inside the perimeter of the area bounded as follows: beginning at the middle anchorage of the western section of the Oakland Bay Bridge (Tower C at 37° 47' 54" N, 122° 22' 40" W) and then in a direct line southeasterly to the Lash Terminal buoy #5 (G"5" buoy, flashing green 4s at 37° 44' 23" N, 122° 21' 36" W), and then in a direct line southeasterly to the easternmost point at Hunter's Point (Point Avisadero at 37° 43' 44" N, 122° 21' 26" W) and then in a direct line northeasterly to the Anchorage #9 buoy "A" (Y"A" buoy, flashing yellow 4s at 37° 44' 46" N, 122° 19' 25" W) and then in a direct line northwesterly to the Alameda N.A.S. entrance buoy #1 (G"1" buoy, flashing green 4s at the entrance to Alameda Carrier Channel (37° 46' 38" N, 122° 20' 27" W) and then in a direct line northwesterly to the Oakland Harbor Bar Channel buoy #1 (G"1" buoy, flashing green 2.5s at 37° 48' 15" N, 122° 21' 23" W) and then in a direct line southwesterly to the point of beginning, Oakland Bay Bridge (Tower C at 37° 47' 54" N, 122° 22' 40" W).

(2) Tomales Bay. Tomales Bay is defined as the waters of District 10 lying south of a line drawn west, 252° magnetic, from the western tip of Tom's Point (38° 12' 53" N, 122° 57' 11" W) to the opposite shore (38° 12' 44" N, 122° 57' 42" W).

(3) Humboldt Bay. Humboldt Bay is defined as the waters of Districts 8 and 9.

(4) Crescent City. Crescent City is defined as Crescent City Harbor and that area of the waters of District 6 less than 20 fathoms in depth between two nautical measure lines drawn due east and west true from Point Saint George (41° 47' 07" N, 124° 15' 16" W) and Sister Rocks (41°, 39' 31" N, 124° 08' 43" W).

(5) No boats or nets shall be operated or set in violation of existing state regulations applying to the navigation or operation of fishing vessels in any area including but not limited to San Francisco Bay, Tomales Bay, Humboldt Bay and Crescent City Harbor.

(6) All fishing for herring in ocean waters (except as specified above) is prohibited. An incidental allowance of no more than 10 percent herring by weight of any load composed primarily of other coastal pelagic fish species or market squid may be landed.

(b) Fishing Season.

(1) The season shall be open from 5:00 p.m. on January 2, and close at 12:00 pm on March 15.

(A) If the opening date falls on a Friday or Saturday, fishing shall commence on the first Sunday following January 2 at 5:00 p.m.

(B) If the closing date of the fishery falls on a Saturday or Sunday, fishing shall close on the Friday immediately preceding March 15 at 12:00 pm.

(c) Gear Requirements. herring may be taken via set gill nets that meet the following requirements:

(1) Net Length.

(A) San Francisco Bay herring permit holders and Tomales Bay herring permit holders shall fish no more than a total of two (2) gill nets that are 65 fathoms (one shackle) or less each in length, as measured at the cork line. Temporary permit holders shall fish no more than one (1) gill net that is 65 fathoms (one shackle) or less in length, as measured at the cork line, for each Temporary permit held. Said gill nets shall not exceed 120 meshes in depth.

(B) In Humboldt Bay and Crescent City Harbor, no permittee shall fish in combination more than 150 fathoms of gill net. Said gill nets shall not exceed 120 meshes in depth.

(2) Mesh Length. Length of the mesh shall be the average length of any series of ten (10) consecutive meshes measured from the inside of the first knot and including the last knot when wet after use; the ten (10) meshes, when being measured, shall be an integral part of the net as hung and measured perpendicular to the selvages; measurements shall be made by means of a metal tape measure while ten (10) meshes are suspended vertically under one-pound weight, from a single stainless steel peg or nail of no more than 5/32 inch in diameter.

(A) In San Francisco Bay and Tomales Bay the average length of the meshes of any gill net used or possessed in the fishery shall not be less than 2 or greater than 2 1/2 inches, and the length of any series of ten (10) consecutive meshes as determined by the above specifications shall not be less than 20 inches or greater than 25 inches.

(B) In Humboldt Bay and Crescent City Harbor the length of the meshes of any gill net used or possessed in the fishery shall not be less than 2 1/4 inches or greater than 2 1/2 inches, and the length of any series of ten (10) consecutive meshes as determined by the above specification shall not be less than 22 1/2 inches or greater than 25 inches.

(3) Set gill nets shall be anchored by not less than 35 pounds of weight at each end, including chain; however, at least one-half of the weight must be anchor.

(4) Gill nets shall be marked at both ends with a buoy displaying above its waterline, in Roman alphabet letters and Arabic numerals at least 2 inches high, the official number of the vessel from which such gill net is being fished. Buoys shall be lighted at both ends using matching white or amber lights that may be seen for at least a distance of 100 yards and marked at both ends with matching flags or markers or placards, all of rigid or non-collapsible material of the same color, on a staff at least 3 feet above the water at each end, bearing the fishing vessel number in contrasting 4 inch black letters.

(d) Net Tending. Permitted vessels shall be in the immediate proximity, not exceeding one nautical miles, of any single gill net being fished.

(e) Temporal Closures. Herring fishing is not permitted from noon Friday through 5:00 p.m. Sunday.

(f) Noise. All San Francisco Bay herring permittees, vessel operators, or crew shall recognize city ordinances governing transient noise sources, when fishing within 500 feet of any shoreline with residential dwellings, between the hours of 10:00 p.m. and 7:00 a.m. through implementation of noise reduction measures specified or developed by the herring fishing industry and approved by the department. Noise reduction measures include, but are not limited to: noise dampening devices for shakers and anchor chains, muffled engine exhaust systems, limited use of deck speakers, and/or reduced speed within 500 feet of shore.

(g) Marine Mammals. The use of explosives, seal bombs, or marine mammal deterrent devices in the herring fishery is prohibited.

(h) Retention and Discards. All fish taken by gill nets shall be retained and landed except sturgeon, halibut, salmon, steelhead and striped bass may not be taken by or possessed on any vessel operating under the authority of these regulations. All sturgeon, halibut, salmon, steelhead and striped bass shall be returned immediately to the water.

(i) Notification Requirements.

(1) Permittees shall notify the department using the contact information designated on the permit within 24 hours of beginning fishing for the season.

(2) Permittees shall notify the department using the contact information designated on the permit, within 24 hours if they terminate fishing operations for the season prior to the overall quota being taken.

(j) Landing Requirements.

(1) Herring shall not be landed between the hours of 10:00 p.m. and 6:00 a.m. on weekdays, or from 10:00 p.m. Friday to 6:00 a.m. Monday.

(2) It is unlawful to transfer herring or herring nets from one permittee to another or from one boat to another except that non-motorized lighters may be used, provided they do not carry aboard any gear capable of taking herring, including net reels, and that the catches of not more than one permittee are aboard the lighters at any time. Permit vessels shall not serve as lighters for other permit boats.

(3) A permittee and his/her gear must stay together when delivering fish to market.

(4) Any herring taken for commercial purposes shall only be delivered to a person licensed pursuant to Section 163.5, of these regulations.

(5) The department will estimate from the current catch rate the time at which the herring season catch is estimated to reach any quota established in accordance with Section 55.02(d) of these regulations and will publicly announce that time on VHF/Channel 16. It shall be the responsibility of all permittees to monitor this radio channel at all times. Any announcement made by the department on VHF/Channel 16 shall constitute official notice. All fishing gear must be removed from the water by the announced time terminating fishing operations. The department may announce a temporary closure for the gill net fishery in order to obtain an accurate tally of landings and to allow all boats to unload. If the fishery is reopened, permittees

may be limited to equally-allotted tonnages to preclude exceeding a quota, as may be announced, and, if necessary, additional time may be granted to reach the quotas.

(6) All herring landed in excess of any established quota shall be forfeited to the department by the signing of a Release of Property Form FG-MR-674, as set forth in subsection 163(c). Such fish shall be sold or disposed of in a manner determined by the department. The proceeds from all such sales shall be paid into the Fish and Game Preservation Fund.

Note: Authority cited: Sections 7071, 7078, and 8550, Fish and Game Code. Reference: Sections 7071, 7078, and 8550, Fish and Game Code.

Proposed Regulatory Language

Section 163.5, Title 14, CCR, is amended to read:

§ 163.5. ~~Penalties in Lieu of Suspension or Revocation -Herring Permittees~~ Herring Buyer's Permit.

~~(a) Pursuant to the provisions of section 309 of the Fish and Game Code and sections 163 and 746, Title 14, CCR, any permit issued pursuant to Section 8550 of the Fish and Game Code may be suspended or revoked at any time by the Commission for cause, after notice and an opportunity to be heard, or without a hearing upon conviction of the permittee or his/her substitute (pursuant to Section 163, Title 14, CCR) of a violation of Fish and Game Code statutes or Division 1, Title 14, CCR, while fishing as a participant in the herring fishery by a court of competent jurisdiction. A permittee whose permit has been suspended or revoked for conviction of a violation of Fish and Game Code statutes or Division 1, Title 14, CCR, while fishing as a participant in the herring fishery may request a hearing before the commission to show cause why his or her herring fishing or buying privileges should be restored.~~

~~(b) Notwithstanding subsection (a), the Executive Secretary of the Commission shall enter into a stipulated compromise settlement agreement with the consent of the permittee for category I violations, and may enter into a compromise for category II violations with the consent of the permittee. The provisions of this section regarding compromise settlement agreements shall not apply if action is brought to recover civil damages under Section 2014 of the Fish and Game Code from the person subject to action under this section.~~

~~(c) Terms and Conditions of a stipulated compromise agreement may include, but are not limited to, the payment of monetary penalties, the reduction of a revocation to a suspension for a specified period of time, a period of probation not to exceed three years or any other terms and conditions, mutually agreed upon by the Executive Secretary acting for the Commission and the permittee, without further hearing or appeal.~~

~~(d) A compromise settlement agreement may be entered before, during or after the Commission hearing on the matter, but is valid only if executed and signed by the Executive Secretary and the permittee prior to the adoption of the decision by the Commission. Any monetary penalty included in a compromise settlement agreement shall be within the range of monetary penalties as prescribed in subsection (f) of these regulations and shall be due and payable within 30 days after the compromise is entered into. Any and all funds submitted as payment in whole or in part by a permittee of any monetary penalties stipulated in a compromise settlement agreement shall be nonrefundable.~~

~~(e) If the permittee fails to perform all of the terms and conditions of the compromise settlement agreement, such agreement is thereby declared void and the Commission, notwithstanding the compromise settlement agreement, may take any action authorized by section 163 of these regulations against the permittee.~~

~~(f) Procedures for determining monetary penalties:~~

~~(1) Monetary penalties (score range multiplied by the monetary range) for compromise settlement agreements shall be based on the following point system:~~

~~SCORE RANGE~~	~~MONETARY RANGE~~
~~(Total Points)~~	
~~1-10~~	~~$200 per point as provided in subsection (f)(2) below.~~

11+	$400 per point as provided in subsection (f)(2) below.

(2) The score range shall be based on a cumulative total of the points assigned in this subsection:

(A) POINTS ASSIGNED FOR CATEGORY I VIOLATIONS ARE AS FOLLOWS:

1. Failure to properly identify vessel (Sec. 163(d))	1 point
2. Improperly marked buoys or flags (Sec. 163(f)(2)(F))	1 point
3. Failure of permittee to have herring permit, commercial	
fishing license, or boat registration aboard the permit	
vessel (Sec. 163, para. 1)	2 points
4. Setting or operating nets within 300 feet of specified	
piers and jetties (Sec. 163(f)(2)(C) and (f)(2)(E))	3 points
5. Failure to “tend” nets (Sec. 163(f)(2)(A))	5 points
6. Failure of herring buyer to permanently mark all	
vehicles, containers or pallets (Sec. 163(j)(1))	5 points

(B) POINTS ASSIGNED FOR CATEGORY II VIOLATIONS ARE AS FOLLOWS:

1. Unloading fish without recovering both nets and	
having them aboard vessel (Sec. 163(e)(4))	6 points
2. Fishing in a closed area (Sec. 163(f)(1) and 163(f)(2)(D))	12 points, plus
	all fish and nets
	on the vessel at
	the time of the
	violation shall
	be forfeited to
	the department
	and such fish and
	nets shall be sold
	or disposed of in
	a manner
	determined by
	the department
	with the
	proceeds from
	all such sales
	paid into the Fish
	and Game
	Preservation
	Fund
3. Failure to remove fishing gear from water by	
announced time terminating fishery operations	
(Sec. 163(e)(3))	6 points,
	plus 1/2 point

	for each hour,
	or portion
	thereof, after
	closing time
4. Possession or use of nets with undersized mesh	
(Sec. 163 (f)(2)(B))	12 points, plus
	all fish and nets
	on the vessel at
	the time of the
	violation shall
	be forfeited to
	the department
	and such fish and
	nets shall be sold
	or disposed of in
	a manner
	determined by
	the department
	with the
	proceeds from
	all such sales
	paid into the Fish
	and Game
	Preservation
	Fund
5. Failure to immediately return all halibut, sturgeon,	
salmon, steelhead and striped bass to the water	
(Sec. 163(e)(6))	10 points
6. Possession or use of extra nets or nets which	
exceed maximum length restrictions (Sec. (f)(2)(A))	12 points,
	plus 1/2 point for
	every 5 fathoms
	of net, or portion
	thereof, exceed-
	ing maximum,
	plus all fish and
	nets on the
	vessel at the time
	of the violation
	shall be forfeited
	to the
	department and
	such fish and
	nets shall be sold

	~~or disposed of in~~
	~~a manner~~
	~~determined by~~
	~~the department~~
	~~with the~~
	~~proceeds from~~
	~~all such sales~~
	~~paid into the Fish~~
	~~and Game~~
	~~Preservation~~
	~~Fund~~
~~7. Failure of permittee or his or her temporary substitute,~~	
~~authorized by the department, to be aboard the vessel~~	
~~during herring fishing operations (Sec. 163, para 1)~~	~~10 points~~
~~8. Failure to complete and maintain weight tally sheets~~	
~~(Sec. 163(j)(4))~~	~~10 points~~
~~9. Failure to immediately complete a Fish and Game~~	
~~receipt upon completion of weighing any load or~~	
~~lot of fish (Sec. 163(j)(2))~~	~~15 points~~

~~(C) For each prior conviction of the permittee within the past three years for violations of the laws or regulations pertaining to the commercial take of herring:~~
~~1. The following additional points shall be assessed:~~
~~(i) For one prior conviction for a violation of the commercial herring fishing laws or regulations within the past three years, the monetary assessment shall be doubled if the total point score (points from prior violation added to points for current violation) is 10 or less, and tripled if such total point score is 11 points or more.~~
~~(ii) For two prior convictions for violations of the commercial herring fishing laws or regulations within the past three years, the monetary assessment shall be quadrupled if the total point score (points from prior convictions added to points for current violation) is 17 or less.~~
~~2. The permit shall be revoked, or suspended for a period of at least 1 year, if the total point score is 18 points or more.~~
~~(3) Conviction of multiple violations, committed at the same time, shall be treated as one conviction for the purposes of implementing the provisions of this section.~~
~~(4) All monetary penalties for compromise agreements assessed under this section shall be deposited by the Department to the Fish and Game Preservation Fund.~~

(a) Pacific Herring Buyer's Permit. A holder of a current fish receiver's license must obtain a separate permit to buy Pacific Herring or herring eggs on kelp (HEOK) for commercial purposes. After approval of form Herring Buyer's Permit Application DFW 327 and payment of the permit fee specified in Section 705(a), a revocable, nontransferable permit to buy Herring or HEOK for commercial purposes may be issued subject to the following regulations:

(1) The permittee shall permanently mark all vehicles, containers or pallets with individualized serial numbers and predetermined tare weights. The serial number and predetermined tare

weight shall be permanently marked in letters and numerals at least 3 inches high on each side of vehicle container or pallet.

(2) Pursuant to Section 197 of these regulations, an electronic fish ticket (EFT) or dock ticket must be completed immediately upon completion of weighing of any single boatload (hereinafter “load”) of herring or HEOK. If a dock ticket is used, the information recorded therein must be used to complete and submit an EFT within three (3) business days.

(A) The EFT or dock ticket for each vessel’s load must be completed and signed by both the herring permittee and a certified weighmaster or his/her deputy prior to commencing unloading operations of another herring permittee's load.

(B) The weighmaster or deputy submitting the EFT must include all information required by Section 197 of these regulations and shall sign the EFT and/or dock ticket with his/her complete signature. For herring, the weighmaster shall list the number of fish in, and the weight of, each roe test for the landing reported.

(C) Any completed dock ticket must be retained with the EFT by the weighmaster or deputy and be immediately available to the department at the weigh station, as per Section 197 of these regulations.

(D) Up to ten (10) pounds of herring from each load will be made available by the herring buyer to the department, at no cost, for management purposes. No herring shall be taken for roe percentage testing purposes from a load that has not first been weighed and recorded.

(3) Prior to weighing HEOK, each permittee shall have each weighing device currently certified and sealed by the County Division of Weights and Measures.

(4) Weight tally sheets shall be used when any load of fish is divided and placed into more than one container prior to the completion of the landing receipt. Weight tally sheets shall include the time unloading operations begin.

(A) The tally sheets shall comprise of four columns:

1. The serial or I.D. number of all containers in which the load is initially placed and all subsequent containers, if any, in which the load is placed until, and including for, shipment from the buyer's premises.

2. The gross weight;

3. The tare weight of the bin or containers; and

4. The net weight excluding the gross weight of each bin or container. For whole fish, this includes the weight of the herring taken for testing purposes. For HEOK, this excludes the salt and brine.

(B) The weight tally sheets shall be retained by the permittee for one (1) year and must be available at all times for inspection by the department.

(C) When requested by the department, the buyer shall submit to the department a California Highway Patrol weighing certificate for any truck load designated by the department. Such certificate shall be submitted to the department following the instructions on the Herring Buyers Permit within twenty-four (24) hours of the truck's departure from the buyer’s premises.

(5) The permittee is responsible to ensure that all provisions of the herring buyer's permit are complied with, even though the tasks may be delegated to others.

(6) The permit may be revoked by the department upon violation of any provisions contained herein by the holder of the permit, his/her agents, employees, or those acting under his/her direction or control and shall not be renewed for a period of one (1) year from the date of revocation.

Note: Authority cited: Sections 7071, 8032.5 and 8389, Fish and Game Code. Reference: Sections 7071, 8032, 8032.5, 8033 and 8389, Fish and Game Code.

Proposed Regulatory Language

Section 164, Title 14, CCR, is amended to read:

§ 164. Harvest of Herring Eggs on Kelp.

~~(a) Herring eggs may be taken for commercial purposes only under a revocable, nontransferable permit issued by the department. A department-issued copy of the permit shall be aboard each vessel harvesting, processing or transporting herring eggs under the authority of the permit. The permittee or his/her authorized agent shall be aboard any vessel that is harvesting, processing or transporting herring eggs under the authority of the permit. The permit shall list the names of all authorized agents and all vessels used for harvesting, processing or transporting herring eggs under the authority of the permit (This includes the attachment of any changes approved by the department after the permit is issued).~~

~~(b) Herring eggs may be harvested only from the waters of San Francisco Bay. The harvest season is December 1 to March 31.~~

~~(c) For purposes of this section, San Francisco Bay is defined as the waters of Fish and Wildlife districts 11, 12, 13 and that part of district 2 known as Richardson Bay.~~

~~(d) No more than 11 permits may be issued under the provisions of these regulations. No new permits shall be issued until the maximum number of permits is less than 10. The commission will review and determine annually whether further action, other than permit attrition, is deemed necessary to achieve a reduction to 10 permits.~~

~~(e) Fishing, Harvesting, and Processing Defined. Unless the context requires otherwise, the following definitions shall apply to the herring eggs on kelp (HEOK) fishery:~~

~~(1) "Fishing" means the act of suspending giant kelp (*Macrocystis pyrifera*) for the purposes of taking herring eggs, and/or the subsequent act of removing herring eggs on kelp from the water for the purposes of transport or harvest. Any person engaged in fishing shall possess a commercial fishing license pursuant to Section 7850 of the Fish and Game Code.~~

~~(2) "Harvesting" means the act of removing herring eggs on kelp from the water for the purposes of processing for sale and/or transport to market. Any person engaged in harvesting shall possess a commercial fishing license pursuant to Section 7850 of the Fish and Game Code.~~

~~(3) "Processing" means the act of separating or removing kelp blades (with herring eggs attached) from the stipe of harvested herring eggs on kelp, and loading the processed blades into bins or totes. Any person engaged in, or employed for the specific purpose of, processing herring eggs on kelp shall fall under the category of nonapplicability in regard to possession of a commercial fishing license pursuant to Section 7850.5 of the Fish and Game Code. Pursuant to Section 7850.5 of the Fish and Game Code, a person engaged in processing (permittees and authorized agents excepted) may stand aboard a herring eggs on kelp vessel while at a dock or landing, but may not be transported aboard the vessel. A person engaged in processing (permittees and authorized agents excepted) may not stand on the herring eggs on kelp raft, nor physically participate in the removal of herring eggs on kelp from the water.~~

(f) Permits. Permits shall be issued in two categories:

(1) Prior permittee. Permits shall be issued to all prior permittees. A prior permittee is defined as a person who has:

(A) met the requirements under subsection (g) of these regulations, and

(B) renewed their herring eggs on kelp permit for the immediately preceding herring eggs on kelp season, and

(C) submitted all fees from prior seasons.

(2) New permittee. A new permittee is defined as any applicant who held a herring permit issued pursuant to Section 163 of these regulations during the preceding herring season, but does not qualify as a prior permittee as defined above. The total number of permits available to new permittees shall be the difference between the 10 permit limit and the number of permits issued to individuals qualifying as prior permittees. In the event that the number of eligible applicants qualifying for new permits exceeds the number of available permits, a lottery shall be held.

(g) Permit conditions: Every person operating under a permit to harvest herring eggs shall:

(1) Forfeit his or her herring fishing privileges authorized pursuant to Section 163 of these regulations during the same season.

(2) In addition to any license fees required by the Fish and Game Code, pay a royalty of $500 per ton of herring eggs on kelp taken. (The royalty fee shall include the landing tax imposed pursuant to Article 7.5, (commencing with Section 8040) Chapter 1, Part 3, Division 6, of the Fish and Game Code, and the royalty fee required for the harvesting of kelp pursuant to Section 165, Title 14 CCR).

(3) Submit a Herring-Eggs-on-Kelp Monthly Landings and Royalty Report (DFW 143 HR (REV. 06/04/15), which is incorporated by reference herein (available at the department's License and Revenue Branch, Sacramento), with payment due to the department's License and Revenue Branch, Sacramento for each month of the season, within 60 days after the close of the month for which it is due.

(h) Permit applications. Each applicant for a herring eggs on kelp permit shall:

(1) Submit the completed application as specified in Section 705, Title 14, CCR, to the address listed on the application for the season to which the application applies. No person shall submit more than one application per season. Applications shall include a performance deposit as specified in subsection (i).

(2) Permit Renewal. Applications for renewal of all Herring-Eggs-on-Kelp permits shall be received by the department, or if mailed, postmarked, on or before the first Friday of October each year. Late fees, late fee deadlines, and late renewal appeal provisions are specified in Fish and Game Code Section 7852.2.

(3) Have submitted all fees from prior seasons.

(i) Each application shall include a performance deposit equal to 50% of the royalty price for the permit (i.e., allotment). The deposit shall be credited to the amount payable by the successful applicants and shall not be refundable. The performance deposit shall be returned to an applicant who does not qualify for a permit.

(j) Method of Take. Herring eggs may only be taken by harvesting giant kelp (*Macrocystis* sp.), with spawn (i.e., eggs) attached, which has been artificially suspended using the following two methods: rafts and/or lines, a technique commonly known as the "open pond" method. For the purpose of this Section, a raft is defined as a temporary, mobile structure with a metal, wood or plastic frame. The total surface area of each raft is not to exceed 2,500 square feet. Rafts used by a licensed herring eggs on kelp permittee, prior to the 1995-96 season, are exempt from these size specifications. Such rafts may not be modified to exceed 2,500 square feet total surface area. Any new raft built after the 1995-96 herring eggs on kelp season must meet the specified dimensions. A line is defined as a piece of line of no more than 1,200 feet in overall length that is suspended under a suitable permanent structure (e.g., pier or dock), or between two permanent structures (e.g., piers or docks). Kelp lines shall have floats or cork over the entire length of line. Each end of the line must be attached to a permanent structure. Kelp lines suspended from a permanent structure (e.g., pier or dock) shall not be placed as to hinder navigation. If kelp lines are suspended under a permanent structure (e.g., pier or dock), or if a raft is tied up to a permanent structure (e.g., pier, dock or rock wall, natural stationary shoreline structures), the permittee shall obtain prior written approval from the appropriate owners or controlling agency (e.g., wharfinger, Coast Guard, Navy or private owner). Buoys are not permanent structures.

(1) Not more than two rafts and/or two lines may be used per permit. Two permits may be simultaneously fished on the same raft if each line on the raft is clearly identified with the permit number of the owner. Each raft shall have a light at each corner that may be seen for at least a distance of 100 yards. Each raft shall be further identified with the herring eggs on kelp permit number in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background permanently affixed to the raft. Lines shall be marked at the beginning and the end with a light that may be seen for at least a distance of 100 yards. Each line shall be further identified with the herring eggs on kelp permit number in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background, permanently affixed to the line.

(2) Not more than 10 sets of test kelp may be used per permit. Test kelp is defined as one stipe with blades, attached to a length of line for the purpose of testing for spawning activity. A set is defined as one length of line with test kelp attached. Each set must be attached to a permanent structure (e.g., pier, dock) and marked with the herring eggs on kelp permit number, in Roman alphabet letters and Arabic numerals at least 3 inches high, at a point above the waterline. No herring eggs on kelp shall be retained from test kelp sets for testing purposes that have not been weighed and recorded, pursuant to subsection 164(k).

(3) Rafts and/or lines may not be placed in any waters or areas otherwise closed or restricted to the use of herring gill nets operating pursuant to Section 163 of these regulations, except where written approval is granted by the owners or controlling agency (e.g., Navy, Coast Guard). Rafts and/or lines may be placed in Belvedere Cove or Richardson Bay, only if permittees tie their rafts and/or lines to a

~~permanent structure (e.g., pier, dock or rock wall, natural stationary shoreline structures), and obtain prior written approval. Buoys are not permanent structures.~~

~~(4) The total amount of herring eggs on kelp that may be harvested by each permittee shall be based on the previous season's spawning population assessment of herring in San Francisco Bay, as determined by the department. This assessment is used to establish the overall herring fishing quotas pursuant to Section 163 of these regulations. Each herring eggs on kelp permittee is allocated a quota equal to approximately 1.0 percent of the quota.~~

~~(5) Each vessel operating under or assisting in fishing operations under a permit issued pursuant to these regulations shall have a current Fish and Wildlife commercial boat registration and be further identified with the permittee's herring eggs on kelp permit number in 14-inch high, 2-inch wide black Roman alphabet letters and Arabic numerals painted on a white background permanently affixed to each side of the vessel. If a herring eggs on kelp vessel is also used as an assist vessel in another permittee's fishing operation, it must be identified with the number of the permit it is assisting.~~

~~(6) The permittee shall notify the department's License and Revenue Branch, Sacramento in writing with the name and department registration number issued pursuant to Section 7881 of the Fish and Game Code of any vessel that will be used for harvesting, processing or transporting herring eggs under the authority of the permit. The permittee shall receive written approval from the department before using a vessel for harvesting, processing or transporting herring eggs.~~

~~(7) Permittee shall notify the department's Santa Rosa Marine Region office at the telephone number designated on the herring eggs on kelp permit within a 4-hour period prior to the suspension of kelp on a raft and/or lines and supply the following information:~~

~~(A) Where the kelp suspension will take place; and~~

~~(B) Where the permittee plans to fish the rafts and/or lines; and~~

~~(C) A local fax number or mailing address where confirmation of kelp suspension notification can be sent.~~

~~(k) Harvesting, Landing and Processing Requirements. Every person who harvests, receives, processes or wholesales herring eggs shall comply with the following requirements.~~

~~(1) Obtain all appropriate commercial fish business licenses and permits required by Fish and Game Code sections 8030-8038.~~

~~(2) Permittee shall notify the department's Santa Rosa Marine Region office at the telephone number designated on the herring eggs on kelp permit a minimum of 12 hours prior to harvesting herring eggs on kelp on a weekday and supply the following information: description and point of departure of the vessel used; the exact location of each raft and/or line and estimated time of beginning of each operation; and if harvesting occurs, the point of landing and time of landing or off-loading of the herring eggs on kelp harvested. If any of this information changes after notification is given, the permittee shall again notify the department at the telephone number designated on the herring eggs on kelp permit.~~

(3) Herring eggs on kelp may be harvested any time on weekdays, but shall not be off-loaded between the hours of 10:00 p.m. and 6:00 a.m.

(4) Herring eggs on kelp may be harvested on Saturdays and Sundays at any time if the permittee reimburses the department for the cost of operations. The department shall submit a detailed invoice of its cost of operations within 30 days of providing the services. Permittee shall remit payment to the department within 30 days of the postmark date of the department's invoice. Permittee shall notify the department at the phone number designated on the herring eggs on kelp permit, during normal business hours (between 8:00 a.m. and 5:00 p.m., Mondays through Friday) prior to harvesting herring eggs on kelp on Saturday or Sunday, and shall supply the following information:

(A) Description and point of departure of the vessel used.

(B) The exact location of each raft and estimated time of the beginning of the harvesting operation, the estimated time of off-loading of the harvested product, and the point of off-loading.

(C) A local telephone number of the permittee for the immediate confirmation or clarification of the information required in subsection 164(k)(4).

(5) Permittee shall have a certified scale aboard the vessel at all times if any brining is conducted aboard that vessel. This scale shall be used to determine the total weight of herring eggs on kelp prior to brining. For the purposes of this section, all portions of the kelp blade, including all trimmed-off portions (trim), shall be considered part of the harvested product and included in the total weight of herring eggs on kelp. The stipe and pneumatocyst shall not be considered a part of the harvested product; therefore, the weight of the stipe and pneumatocyst shall not be considered in determining the total weight of herring eggs on kelp.

(6) All bins or totes shall be permanently marked with individualized serial numbers, beginning with the prefix CA, and predetermined tare weights (including lids). The serial number and predetermined tare weight shall be permanently marked in letters and numerals at least 3 inches high on each side of the bin or tote.

(7) Prior to weighing herring eggs on kelp, each receiver of herring eggs on kelp shall have a scale currently certified and sealed by the County Division of Weights and Measures.

(8) Weight tally sheets and a landing receipt shall be immediately completed upon the landing and weighing of any single permittee's boat load of harvested herring eggs on kelp (hereinafter “load”).

(A) The landing receipt for each herring eggs on kelp permittee shall be completed and signed by the permittee prior to commencing unloading operations of another permittee's load.

(B) The landing receipt for each load shall include all information required by Fish and Game Code Section 8043. Tally sheets shall indicate the serial number, the tare weight of the bin or tote, the net weight of the product (eggs on kelp), excluding the salt and brine and the gross weight of each bin or tote. Filled bins or totes shall be weighed when landed on-shore, or before they are moved from the premises if processing takes place on-shore. The weight tally sheet shall be retained by the permittee for one year and shall be available at all times for inspection by the department. All herring eggs on kelp landed in excess of any established permit quota shall be forfeited to the department by the

~~signing of a Release of Property form (FG-MR-674 (Rev. 5/13)), which is incorporated by reference herein). Such excess of herring eggs on kelp shall be sold or disposed of, and the proceeds from all such sales shall be paid into the Fish and Game Preservation Fund.~~

~~(9) There shall be no landing or off-loading of herring eggs on kelp from a permittee's vessel, from 10:00 p.m. Friday to 6:00 a.m. Monday, unless brining is conducted at a shore-based facility. If brining occurs on-shore, the permittee shall notify the department's designated contact 12 hours prior to the shipping or removal of the bins or totes from the premises.~~

~~(*l*) These regulations and all sections of the Fish and Game Code pertaining thereto shall be set forth in all permits. Permits shall be issued upon the conditions contained in the application and signed by the applicant that he has read, understands, and agrees to be bound by all terms of the permit.~~

~~(m) A permit may be suspended by the Department of Fish and Wildlife for breach or violation of the terms of the permit by the permittee, or any other person(s) operating under the terms of the permit. Any such suspension may be appealed to the commission pursuant to section 746 of these regulations.~~

~~(n) Authorized agents. Each herring eggs on kelp permittee may designate two authorized agents to operate under his or her permit. To designate an authorized agent, the permittee shall submit to the department's License and Revenue Branch, Sacramento a completed, signed Authorized Agent Form (MRD 164 (8/97)) which is incorporated by reference herein. A permittee may replace an authorized agent by submitting a new Authorized Agent Form to the department's License and Revenue Branch, Sacramento. A copy of the current California commercial fishing license for each authorized agent shall be submitted with each Authorized Agent Form. A person designated on the Authorized Agent Form shall act as an authorized agent only after the permittee has received written approval from the department. An authorized agent:~~

~~(1) May serve in the place of the permittee for all fishery activities requiring the presence or action of the permittee, including the signing of landing receipts;~~

~~(2) Shall possess a current California commercial fishing license;~~

~~(3) Shall not be another herring eggs on kelp permittee unless the other permittee has stopped fishing his or her permit for the season;~~

~~(4) Who does not hold a herring eggs on kelp permit, may act as an authorized agent for more than one herring eggs on kelp permittee.~~

(a) Definitions. Herring Eggs on Kelp (HEOK) may only be taken by harvesting giant kelp (*Macrocystis pyrifera*), with spawn (i.e. eggs) attached, which has been artificially suspended using the following two (2) methods: rafts and/or lines, a technique commonly known as the “open pound” method. Unless the context requires otherwise, the following definitions shall apply to the HEOK fishery:

(1) “Fishing” means the act of suspending giant kelp (*Macrocystis pyrifera*) for the purposes of taking herring eggs, and/or harvesting.

(2) “Harvesting” means the act of removing HEOK from the water for the purposes of processing for sale and/or transport to market.

(3) “Processing” means the act of separating or removing kelp blades (with herring eggs attached) from the stipe of harvested HEOK, trimming the product, brining, grading the product, and loading the processed blades into bins or totes.

(4) A raft is defined as a temporary, mobile structure with a metal, wood or plastic frame. The total surface area of each raft is not to exceed 2,500 square feet.

(5) A line is defined as a piece of line of no more than 1,200 feet in overall length that is suspended under a suitable permanent structure (e.g., pier or dock), or between two permanent structures (e.g., piers or docks).

(b) Area Restrictions.

(1) HEOK may be harvested only from the waters of San Francisco Bay. For purposes of this section, San Francisco Bay is defined as the waters of Fish and Wildlife Districts (District) 11, 12, 13 and that part of District 2 known as Richardson Bay.

(2) Rafts and/or lines may not be placed in any waters or areas otherwise closed or restricted to the use of herring gill nets operating pursuant to Section 163.1 of these regulations, except where written approval is granted by the owners or controlling agency (e.g., Navy, Coast Guard).

(3) Rafts may be placed in Belvedere Cove or Richardson Bay only if they are tied to a permanent structure (e.g., pier, dock or rock wall, natural stationary shoreline structures), and permittees have obtained prior written approval. Buoys are not permanent structures.

(c) Fishing Season. HEOK fishing season is December 1 to March 31.

(d) Gear Requirements.

(1) Not more than two (2) rafts; or two (2) lines; or one (1) raft and one (1) line may be used per permit.

(A) Each raft shall have a light at each corner that may be seen for at least a distance of 100 yards.

(B) Each raft shall be further identified with the fishing vessel number the HEOK permit has been assigned to in Roman alphabet letters and Arabic numerals at least 14 inches high and 2 inches wide, painted on a white background and permanently affixed to the raft.

(C) Kelp lines shall have floats or cork over the entire length of line.

(D) If kelp lines are suspended under a permanent structure (e.g., pier or dock), or if a raft is tied up to a permanent structure (e.g., pier, dock or rock wall, natural stationary shoreline structures), the permittee shall obtain prior written approval from the appropriate owners or controlling agency (e.g., wharfinger, Coast Guard, Navy or private owner). Buoys are not permanent structures.

(E) Lines shall be marked at the beginning and the end with a light that may be seen for at least a distance of 100 yards.

(F) Each line shall be further identified at each end with a contrasting-colored buoy displaying above its waterline, in Roman alphabet letters and Arabic numerals at least 2 inches high, the official number of the vessel from which such net is being fished.

(e) Notification Requirements.

(1) Permittees shall notify the department using the contact information designated on the HEOK permit within a 12-hour period prior to beginning the following activities:

(A) The suspension of kelp on a raft and/or lines.

(B) Harvest of HEOK.

(C) Landing of HEOK.

(2) Permittees shall supply the vessel registration number, departure point of vessel, location of each raft, estimated suspension/landing/harvest time, point of landing, and contact number.

(3) If any of this information changes after notification is given, the permittee shall again notify the department using the contact information designated on the HEOK permit.

(f) Noise. All permittees, authorized agents, vessel operators, crew, or employees shall recognize city ordinances governing transient noise sources, when fishing within 500 feet of any shoreline with residential dwellings, between the hours of 10:00 p.m. and 7:00 a.m. through implementation of noise reduction measures specified or developed by the herring fishing industry and approved by the department. Noise reduction measures include, but are not limited to: noise dampening devices for shakers and anchor chains, muffled engine exhaust systems, limited use of deck speakers, and/or reduced speed within 500 feet of shore.

(g) Marine Mammals. The use of explosives, seal bombs, or marine mammal deterrent devices in the HEOK sector is prohibited.

(h) Landing Requirements

(1) For the purposes of this section, all portions of the kelp blade, including all trimmed-off portions (trim), shall be considered part of the harvested product and included in the total weight of HEOK. The stipe and pneumatocyst shall not be considered a part of the harvested product; therefore, the weight of the stipe and pneumatocyst shall not be considered in determining the total weight of HEOK.

(2) All bins or totes shall be permanently marked with individualized serial numbers, beginning with the prefix CA, and predetermined tare weights (including lids). The serial number and predetermined tare weight shall be permanently marked in letters and numerals at least 3 inches high on each side of the bin or tote.

(3) Filled bins or totes shall be weighed when landed on-shore, or before they are moved from the premises if processing takes place on-shore.

(4) HEOK shall not be landed/off- loaded between the hours of 10:00 p.m. and 6:00 a.m. on weekdays, or from 10:00 p.m. Friday to 6:00 a.m. Monday.

(5) Any HEOK taken for commercial purposes shall only be delivered to a person having a Herring Buyer's Permit pursuant to subsection 163.5(a) of these regulations.

(6) All HEOK landed in excess of any quota established in accordance with Section 55.02(d) of these regulations shall be forfeited to the department by the signing of a Release of Property Form FG-MR-674, as set forth in subsection 163(c). Such excess of HEOK shall be sold or disposed of, and the proceeds from all such sales shall be paid into the Fish and Game Preservation Fund.

(i) Processing Requirements.

(1) Any person engaged in, or employed for the specific purpose of, processing HEOK shall fall under the category of non-applicability in regard to possession of a commercial fishing license pursuant to Section 7850.5 of the Fish and Game Code. Pursuant to Section 7850.5 of the Fish and Game Code, a person engaged in processing (permittees and authorized agents excepted) may stand aboard a HEOK vessel while at a dock or landing, but may not be transported aboard the vessel. A person engaged in processing (permittees and authorized agents excepted) may not stand on the HEOK raft, nor physically participate in the removal of HEOK from the water.

(2) Permittee shall have a certified scale aboard the vessel at all times if any brining is conducted aboard that vessel. This scale shall be used to determine the total weight of HEOK prior to brining.

Note: Authority cited: Sections 7071, 7078, 8389 and 8550, Fish and Game Code. Reference: Sections 7071, 8389 and 8550, Fish and Game Code.

REGULATORY TEXT

Subsections (a) and (b) of Section 705, Title 14, CCR, are **amended** to read:

§ 705. Commercial Fishing Applications, Permits, Tags and Fees.

(a) Application	*Permit Fees (US$)*	*Processing Fees (US$)*
. . . [No changes to subsections (a)(1) through (2)]		
(3) ~~2013-2014~~ 2019-2020 Herring Buyer's Permit ~~FG 327 (Rev 6/13)~~ Application DFW 327 (New 4/11/19), incorporated by reference herein.	~~1,020.75~~ 1,122.00	
(4) ~~2013-2014~~ Herring-Eggs-on-Kelp Permit Application ~~FG 1406 (Rev 6/13)~~ DFW 1406 (New 4/11/19), incorporated by reference herein.		
(A) Herring-Eggs-On Kelp Permit (Resident)	401.50	
(B) Herring-Eggs-On-Kelp Permit (Non-resident)	1,494.00	
(5) *[subsection reserved]* ~~2013-2014 Herring Fresh Fish Market Permit Application FG 329 (Rev. 7/13), incorporated by reference herein.~~	~~40.75~~	
(6) ~~2013-2014~~ Commercial Herring Permit Worksheet ~~FG 1377 (Rev. 7/13),~~ DFW 1377 (New 4/11/19), incorporated by reference herein.		
(A) San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Herring Permit (Resident)	401.50	
(B) San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City Herring Permit (Non-resident)	1,494.00	
(C) Temporary Permit – Renewal Only (Resident)	401.50	
(D) Temporary Permit – Renewal Only (Non-resident)	1,494.00	
(E) Drawing Fee for Applications for New Herring Permits		$4.50

. . . [No changes to subsections (a)(7) through (8)]		
(b) Transfer, Upgrade, or Change of Ownership	*Fees (US$)*	
. . . [No changes to subsections (b)(1) through (10)]		
(11) ~~2013-2014~~ Season Request for Changes to Herring Permits ~~FG 1322-2 (Rev. 6/13),~~ DFW 1322-2 (New 4/11/19), incorporated by reference herein.		
(A) ~~Temporary Substitute~~ Permit Transfer	~~$ 50.00~~ 1,000.00	
(B) Boat Transfer	50.00	
(C) Simultaneous Fishing	No fee	

. . . [No change to subsection (c)]

(d) Pursuant to the provisions of Section 699, Title 14, the department shall annually adjust the fees of all licenses, stamps, permits, tags, or other entitlements required by regulations set forth in this section.

Note: Authority cited: Sections 713 and 1050, Fish and Game Code. Reference: Sections 713 and 1050, Fish and Game Code.

STAFF SUMMARY FOR JUN 12-13, 2019

26. PACIFIC HERRING REGULATIONS

Today's Item **Information** ☐ **Action** ☒

Consider authorizing publication of notice of intent to adopt new and amend existing regulations that implement the *California Pacific Herring Fishery Management Plan* (Herring FMP).

Summary of Previous/Future Actions

- **MRC vetting** **Jul 21, 2016–Mar 20, 2019**
- **Today's notice hearing** **Jun 12-13, 2019; Redding**
- Discussion hearing Oct 9-10, 2019; San Diego
- Adoption hearing Dec 11-12, 2019; Sacramento

Background

A draft Herring FMP is being received by FGC (See Agenda Item 25, this meeting), which initiates the process for consideration and adoption. Regulations that would implement the Herring FMP, once adopted, are proposed for concurrent review and adoption; this includes revisions to current recreational and commercial Pacific herring regulations (sections 27.60, 28.60, 163, 163.1, 163.5, 164 and 705) and proposed new regulatory sections (Section 28.62; and Article 6, sections 55.00, 55.01 and 55.02).

The purposes of the proposed implementing regulations are to:

- implement the Herring FMP, produced pursuant to the Marine Life Management Act;
- improve management of the existing commercial fisheries; and
- support the sustainable and orderly use of this natural resource.

The proposed regulations will cover three areas (see Exhibit 2 for full details):

1. Establish new regulations. Add a new Article 6 in Chapter 5.5 and new sections 55.00, 55.01, and 55 that:
    - describe the purpose and scope of the Herring FMP;
    - provide relevant definitions used in the Herring FMP; and
    - describe management processes and strategy.
2. Amend existing recreational herring fishery regulations.
    - Establish a maximum recreational daily take limit (bag)
        I. Options are provided for a bag limit within the range of zero to ten (0-10) gallons, according to the Herring FMP.
        II. FGC will need to select one option.
        III. DFW's recommendation is five gallons, equivalent to about 260 fish or 50 pounds.

3. Amend existing commercial herring fishery regulations.
   - Revise the current permitting and platoon system.
   - Adopt forms and fees consistent with the new herring regulations.

The Herring FMP fulfills FGC's obligation to comply with the California Environmental Quality Act in considering and adopting an FMP and associated implementing regulations.

Significant Public Comments (NA)

Recommendation

FGC staff: Authorize publication of notice as recommended by DFW.

Committee: MRC recommends that FGC amend the Herring FMP implementing regulations as recommended by DFW.

DFW: Authorize publication of notice.

Exhibits

1. DFW memo transmitting initial statement of reasons (ISOR), received May 24, 2019
2. Draft ISOR
3. Draft economic and fiscal impact statement (Std. 399)
4. DFW presentation

Motion/Direction

Moved by ___________ and seconded by ___________ that the Commission authorizes publication of a notice of its intent to amend Section 27.60, et al., related to California Pacific Herring Fishery Management Plan implementing regulations.

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations: SAM Section 6601-6616

ECONOMIC IMPACT STATEMENT

DEPARTMENT NAME	CONTACT PERSON	EMAIL ADDRESS	TELEPHONE NUMBER
Fish and Game Commission	Margaret Duncan, Economist	@wildlife.ca.gov	916-653-4676

DESCRIPTIVE TITLE FROM NOTICE REGISTER OR FORM 400	NOTICE FILE NUMBER
AmendSections163...,164,705,26.5,28.5, Add 28.62,55.0..., Title14 CCR, Harvest of Herring and Herring Eggs	Z

A. ESTIMATED PRIVATE SECTOR COST IMPACTS *Include calculations and assumptions in the rulemaking record.*

1. Check the appropriate box(es) below to indicate whether this regulation:

- ☐ a. Impacts business and/or employees
- ☒ b. Impacts small businesses
- ☐ c. Impacts jobs or occupations
- ☐ d. Impacts California competitiveness
- ☐ e. Imposes reporting requirements
- ☐ f. Imposes prescriptive instead of performance
- ☒ g. Impacts individuals
- ☐ h. None of the above (Explain below):

If any box in Items 1 a through g is checked, complete this Economic Impact Statement.
If box in Item 1.h. is checked, complete the Fiscal Impact Statement as appropriate.

2. The Fish and Game Commission (FGC) (Agency/Department) estimates that the economic impact of this regulation (which includes the fiscal impact) is:

- ☒ Below $10 million
- ☐ Between $10 and $25 million
- ☐ Between $25 and $50 million
- ☐ Over $50 million *[If the economic impact is over $50 million, agencies are required to submit a Standardized Regulatory Impact Assessment as specified in Government Code Section 11346.3(c)]*

3. Enter the total number of businesses impacted: 75 approx.

Describe the types of businesses (Include nonprofits): Commercial Herring permit holders (75) & recreational herring anglers (unknown #)

Enter the number or percentage of total businesses impacted that are small businesses: 100%

4. Enter the number of businesses that will be created: 0 eliminated: 0

Explain: The Pacific Herring (Herring) fishery business stimulus is largely influenced by foreign market demand for Herring and roe.

5. Indicate the geographic extent of impacts: ☐ Statewide

☒ Local or regional (List areas): San Francisco, Tomales, Humboldt, Crescent City Bays

6. Enter the number of jobs created: 0 and eliminated: 0

Describe the types of jobs or occupations impacted: commercial fishing and fish handling jobs

7. Will the regulation affect the ability of California businesses to compete with other states by making it more costly to produce goods or services here? ☐ YES ☒ NO

If YES, explain briefly:

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ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

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ECONOMIC IMPACT STATEMENT (CONTINUED)

B. ESTIMATED COSTS *Include calculations and assumptions in the rulemaking record.*

1. What are the total statewide dollar costs that businesses and individuals may incur to comply with this regulation over its lifetime? $ ______

   a. Initial costs for a small business: $ ______ Annual ongoing costs: $ ______ Years: ______

   b. Initial costs for a typical business: $ ______ Annual ongoing costs: $ ______ Years: ______

   c. Initial costs for an individual: $ ______ Annual ongoing costs: $ ______ Years: ______

   d. Describe other economic costs that may occur: No new fees, compliances costs, or reporting requirements.

2. If multiple industries are impacted, enter the share of total costs for each industry: Commercial Fishing 69%, Petroleum 10%, Real Estate 7%, Professional Service 8%, Food/Beverage 2%, Wholesale Trade 4% with multipliers for direct, indirect, and induced impacts.

3. If the regulation imposes reporting requirements, enter the annual costs a typical business may incur to comply with these requirements. *Include the dollar costs to do programming, record keeping, reporting, and other paperwork, whether or not the paperwork must be submitted.* $ ______

4. Will this regulation directly impact housing costs? ☐ YES ☒ NO

   If YES, enter the annual dollar cost per housing unit: $ ______

   Number of units: ______

5. Are there comparable Federal regulations? ☐ YES ☒ NO

   Explain the need for State regulation given the existence or absence of Federal regulations: Legislature mandates resource mgt. with FGC authority

   Enter any additional costs to businesses and/or individuals that may be due to State - Federal differences: $ N/A

C. ESTIMATED BENEFITS *Estimation of the dollar value of benefits is not specifically required by rulemaking law, but encouraged.*

1. Briefly summarize the benefits of the regulation, which may include among others, the health and welfare of California residents, worker safety and the State's environment: Benefits will accrue to fishermen, processors, and the State's economy in the form of a healthy environment, and maintaining a sustainable herring population, which is quantified each year.

2. Are the benefits the result of: ☐ specific statutory requirements, or ☒ goals developed by the agency based on broad statutory authority?

   Explain: CA legislature mandates sustainable resource mgt. & provides the FGC authority to implement regulations toward that end.

3. What are the total statewide benefits from this regulation over its lifetime? $ ______

4. Briefly describe any expansion of businesses currently doing business within the State of California that would result from this regulation: ______

D. ALTERNATIVES TO THE REGULATION *Include calculations and assumptions in the rulemaking record. Estimation of the dollar value of benefits is not specifically required by rulemaking law, but encouraged.*

1. List alternatives considered and describe them below. If no alternatives were considered, explain why not: None. Managing the herring fishery by establishing quotas, based on best available science, balances environmental and biological safeguards with the potential impacts to ongoing business enterprises.

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE
ECONOMIC AND FISCAL IMPACT STATEMENT
(REGULATIONS AND ORDERS)
STD. 399 (REV. 12/2013)

ECONOMIC IMPACT STATEMENT (CONTINUED)

2. Summarize the total statewide costs and benefits from this regulation and each alternative considered:

Regulation: Benefit: $ 550 - 650 K Cost: $ 0 -10 K

Alternative 1: Benefit: $ 5 K Cost: $ 10 K

Alternative 2: Benefit: $ non-monetary Cost: $ 550 - 650 K

3. Briefly discuss any quantification issues that are relevant to a comparison of estimated costs and benefits for this regulation or alternatives: The future benefits of resource health are difficult to predict given other biological and environmental factors beyond the Agency's control; such systemic benefits are difficult to monetize.

4. Rulemaking law requires agencies to consider performance standards as an alternative, if a regulation mandates the use of specific technologies or equipment, or prescribes specific actions or procedures. Were performance standards considered to lower compliance costs? ☐ YES ☒ NO

Explain: ______

E. MAJOR REGULATIONS *Include calculations and assumptions in the rulemaking record.*

California Environmental Protection Agency (Cal/EPA) boards, offices and departments are required to submit the following (per Health and Safety Code section 57005). Otherwise, skip to E4.

1. Will the estimated costs of this regulation to California business enterprises **exceed $10 million**? ☐ YES ☐ NO

If YES, complete E2. and E3
If NO, skip to E4

2. Briefly describe each alternative, or combination of alternatives, for which a cost-effectiveness analysis was performed:

Alternative 1: ______

Alternative 2: ______

(Attach additional pages for other alternatives)

3. For the regulation, and each alternative just described, enter the estimated total cost and overall cost-effectiveness ratio:

Regulation: Total Cost $ ______ Cost-effectiveness ratio: $ ______

Alternative 1: Total Cost $ ______ Cost-effectiveness ratio: $ ______

Alternative 2: Total Cost $ ______ Cost-effectiveness ratio: $ ______

4. Will the regulation subject to OAL review have an estimated economic impact to business enterprises and individuals located in or doing business in California exceeding $50 million in any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through12 months after the major regulation is estimated to be fully implemented?

☐ YES ☒ NO

If YES, agencies are required to submit a Standardized Regulatory Impact Assessment (SRIA) as specified in Government Code Section 11346.3(c) and to include the SRIA in the Initial Statement of Reasons.

5. Briefly describe the following:

The increase or decrease of investment in the State: ______

The incentive for innovation in products, materials or processes: ______

The benefits of the regulations, including, but not limited to, benefits to the health, safety, and welfare of California residents, worker safety, and the state's environment and quality of life, among any other benefits identified by the agency: ______

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT
(REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations:
SAM Section 6601-6616

FISCAL IMPACT STATEMENT

A. FISCAL EFFECT ON LOCAL GOVERNMENT *Indicate appropriate boxes 1 through 6 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year which are reimbursable by the State. (Approximate)
(Pursuant to Section 6 of Article XIII B of the California Constitution and Sections 17500 et seq. of the Government Code).

$ ____________________

☐ a. Funding provided in ____________________

Budget Act of ____________ or Chapter ____________, Statutes of ____________

☐ b. Funding will be requested in the Governor's Budget Act of ____________________

Fiscal Year: ____________

☐ 2. Additional expenditures in the current State Fiscal Year which are NOT reimbursable by the State. (Approximate)
(Pursuant to Section 6 of Article XIII B of the California Constitution and Sections 17500 et seq. of the Government Code).

$ ____________________

Check reason(s) this regulation is not reimbursable and provide the appropriate information:

☐ a. Implements the Federal mandate contained in ____________________

☐ b. Implements the court mandate set forth by the ____________________ Court.

Case of: ____________________ vs. ____________________

☐ c. Implements a mandate of the people of this State expressed in their approval of Proposition No. ____________

Date of Election: ____________________

☐ d. Issued only in response to a specific request from affected local entity(s).

Local entity(s) affected: ____________________

☐ e. Will be fully financed from the fees, revenue, etc. from: ____________________

Authorized by Section: ____________ of the ____________ Code;

☐ f. Provides for savings to each affected unit of local government which will, at a minimum, offset any additional costs to each;

☐ g. Creates, eliminates, or changes the penalty for a new crime or infraction contained in ____________________

☐ 3. Annual Savings. (approximate)

$ ____________________

☐ 4. No additional costs or savings. This regulation makes only technical, non-substantive or clarifying changes to current law regulations.

☒ 5. No fiscal impact exists. This regulation does not affect any local entity or program.

☐ 6. Other. Explain ____________________

STATE OF CALIFORNIA — DEPARTMENT OF FINANCE

ECONOMIC AND FISCAL IMPACT STATEMENT (REGULATIONS AND ORDERS)

STD. 399 (REV. 12/2013)

Instructions and Code Citations: SAM Section 6601-6616

FISCAL IMPACT STATEMENT (CONTINUED)

B. FISCAL EFFECT ON STATE GOVERNMENT *Indicate appropriate boxes 1 through 4 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year. (Approximate)

$ ______________

It is anticipated that State agencies will:

☐ a. Absorb these additional costs within their existing budgets and resources.

☐ b. Increase the currently authorized budget level for the ______________ Fiscal Year

☐ 2. Savings in the current State Fiscal Year. (Approximate)

$ ______________

☒ 3. No fiscal impact exists. This regulation does not affect any State agency or program.

☐ 4. Other. Explain ______________

C. FISCAL EFFECT ON FEDERAL FUNDING OF STATE PROGRAMS *Indicate appropriate boxes 1 through 4 and attach calculations and assumptions of fiscal impact for the current year and two subsequent Fiscal Years.*

☐ 1. Additional expenditures in the current State Fiscal Year. (Approximate)

$ ______________

☐ 2. Savings in the current State Fiscal Year. (Approximate)

$ ______________

☒ 3. No fiscal impact exists. This regulation does not affect any federally funded State agency or program.

☐ 4. Other. Explain ______________

FISCAL OFFICER SIGNATURE	DATE
Original signature on file 5/3/19	

The signature attests that the agency has completed the STD. 399 according to the instructions in SAM sections 6601-6616, and understands the impacts of the proposed rulemaking. State boards, offices, or departments not under an Agency Secretary must have the form signed by the highest ranking official in the organization.

AGENCY SECRETARY	DATE
Original signature on file 7/3/19	

Finance approval and signature is required when SAM sections 6601-6616 require completion of Fiscal Impact Statement in the STD. 399.

DEPARTMENT OF FINANCE PROGRAM BUDGET MANAGER	DATE

[redacted]

From: FGC
Sent: Thursday, August 8, 2019 7:29 AM
To: Weltz, Andrew@Wildlife
Subject: FW: Herring FMP

From: Kirk Lombard [redacted]
Sent: Wednesday, July 24, 2019 9:19 PM
To: FGC <FGC@fgc.ca.gov>
Subject: Herring FMP

To whom it may concern,

Hi, Kirk Lombard here. I have no idea who is reading this but I wanted to send my thoughts on the proposed changes to the recreational herring fishery. I consider myself a stakeholder in herring because:

1. I am one of the few local fishmongers who actually sells herring to the public (except for last year when the gill netters didn't fish and the herring buyers never showed up).
2. I have blogged, promoted, made youtube videos and written extensively on herring (see *The Sea Forager's Guide* below) over the years.
3. I am an avid sport harvester of herring and have spent a good deal of time trying to get people to understand how awesome they are as a local, healthy, sustainable seafood resource.

In looking at the wording of the proposed bag limit on herring I'm concerned that in trying to establish limits, (which, by the way, I support), the FGC might go too far. A zero to one bucket limit on herring is, in my estimation, an over reaction. As one who has spent a good deal of time thinking about, writing about, eating, and fishing for herring, I am hoping that the commission will please consider my thoughts on the matter.

1. The sport fishery for herring is almost exclusively (but not entirely) a shore-based fishery. As such, there are only on average 10-12 days per season when herring can be caught by shore based net throwers.

2. When the herring are spawning most people content themselves with a few buckets. The problem is the few bad apples out there who feel compelled to fill up the backs of pick up trucks and multiple garbage cans. It seems counter productive to cut the sport bag limit to a bucket or less because of the greed of a few unsportsmanlike fishers.

3. As much as I support the gill net fishery there are some things that should be taken into account when comparing recreational and commercial. For one thing, the sport harvest of herring directly benefits the local populace. Local people fish for, catch, share and eat herring. As much as I would like it to be otherwise, 99.9 percent of the fish caught commercially are shipped to Japan for roe. Other than the few herring buyers (who are generally not local), and the ever decreasing number of commercial herring fishermen, what local people are really benefitting by this amazing resource? How many Bay Area residents even know that Pacific Herring exist? Comparatively few. Why would they know about herring when the fish are shipped overseas and rarely appear in local seafood markets? The quality of gillnetted (read: choked, beaten, stepped on, not-iced, sucked and crushed) herring is infamously poor. Much as I hate to say it, commercially caught herring are not a marquee seafood item. Throw netted herring by contrast are not pulverized and are carried away immediately for processing--my point here is that the public only has a chance to eat a high quality, nutritious fish if they catch them themselves. And again, typically, for the entire Bay Area (from Point Richmond to San Mateo Bridge there are really only 8-12 days where herring are even reachable per year).

4. There can be no denying that sport herring are mostly caught and enjoyed by people of various Asian ethnicities. Anecdotally, I have noticed that most of the people who seem outraged by what they see as over use of the resource are non-Asians and commercial fishermen. I would hope that the commission would take this into account. And please also take into account the evident importance of this fishery as both a source of nutrition and recreation for the Asian and Asian-American communities in San Francisco.

5. To a non herring fisherman one bucket (38 pounds) seems like a lot. But it really is not. This year I had bad luck and a busy schedule and only got one bucket. Those fish lasted about 3 months. Normally I catch 4 buckets and they last all year. Herring freeze well and can be pickled, fried, grilled, eaten on a stick, filleted, turned into fish stock, etc etc. The roe is also quite excellent (as the Japanese kazunoko fans can attest).

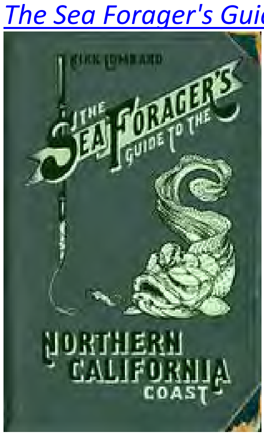
6. Herring are one of the few fish species caught in SF Bay that can be eaten without concern by kids, "women in their child bearing years" and everyone else. The internet abounds with information about the sustainability and positive nutritional benefits of eating small, low on the food chain species. By limiting sport herring to a bucket or less you would be limiting the number of locally available, sustainable, nutritious and culturally significant fish to a fairly large swathe of Bay Area seafood consumers. Especially considering that the few gill netted fish that arrive in the market, are of such low quality.

It is my hope that the conversation of sport limits on herring starts at 2 five gallon buckets. Personally I think it should be 3-4. But two would at least be a reasonable embarkation point. One bucket or less will leave everyone disappointed except the people with a grudge against sport harvest, or a grudge against the people who engage in it.

Thanks for hearing me out.

Kirk Lombard

The Sea Forager's Guide - August, 2016, Heyday



Website * Coastal Update * twitter

[redacted]

From: [redacted]
Sent: Wednesday, August 7, 2019 6:21 AM
To: FGC
Subject: Herring Limits

Hi,
I am a Native San Franciscan, and long time fisherman. The Herring run has been a part of my most enjoyed winter time activities for decades, and is one that I share with friends and family. While I am not in the habit of routinely taking multiple trashcans full, it is not outside of reason for me to fill up 5 to 10 5 gallon buckets.

The Herring I take turns into food mostly, with a large portion of it getting pickled or cured. A small amount gets used for bait, and the rest gets BBQ'd broiled or fried. It is a wonderfully tasty fish (anyone who says otherwise has not given it a proper chance) and with the sporadic spawning locations, the short nature of the spawns, and the relatively low number of recreational fishermen at the spawns (every year its more or less the same 30 to 50 people) it seems like the 2 bucket limit is entirely unfounded, and something that has spawned from two desires:
the first is reasonable, which is an attempt to monitor how much recreational fishermen are taking,
the second is outrageous, and seems to be that a few vocal individuals have a racist agenda and can not comprehend how anyone could use all the herring they are taking. How many times have I seen my acquaintance Kirk Lumbard of Sea Forager making racist comments about people of color at herring spawns, only to see him turn around and do exactly what he is complaining about!

Sorry for the late input, i will understand if this does not make it to public comment. Thank you for all the hard work you do at CDFW.

p.s. - if this does get read at a public hearing, please keep me anonymous.

--
[redacted]

[redacted]

From: b c [redacted]
Sent: Wednesday, July 24, 2019 9:54 AM
To: FGC
Subject: Recreational Herring regulations

Follow Up Flag: Flag for follow up
Flag Status: Flagged

I'm writing to express my displeasure with the proposed 1 bucket limit for the recreational catch of herring. I believe this is too stringent and that a 4 or 5 bucket limit is more reasonable.

Due to the nature of the fishery and the unpredictable spawning patterns it is difficult for recreational fishermen and women to get to an active spawning event. Most are over by the time I even hear about it or has moved on to another location that may or may not be accessible or that I may not have time to follow due to work or family obligations. Some years I've missed out entirely.

Most years, though I get to at least one decent event that allows me to catch enough to stock my freezer for the coming year. I use the herring I take as both table fare and as bait for larger gamefish. One bucket from one event wouldn't last me anywhere close to a year.

Additionally, a 1 bucket limit is overly restrictive on the recreational fisherman in light of the tons that the commercial fleet is allowed to take every year. Our impact is not that great and I've seen no scientific data indicating that the recreational take is impacting the fishery in any meaningful way. In light of this, please reconsider and adopted a limit of no less than 4 buckets per person per day.

Thank you for your consideration.

Bradley S. Cain

Dear Commissioners,
I am writing in regards to the upcoming changes to the recreational herring fishery, specifically the daily bag limit. I am urging you to consider a daily limit of four buckets.

An avid fisherman, I started fishing for herring about eight years ago, and every year I look forward to the annual spawns. When we hear of a spawning event, we drop everything and go to the scene. If we're lucky, the spawn will still be active and we will fill two to four buckets each and call it a day. We take the fish home, freeze them in bags and eat them for months. I had herring for breakfast yesterday. It's a true local and abundant food supply.

Herring fishing is difficult to time correctly. Often we will arrive at a spawn only to find out there was never a spawn at all or that it has already ended and the fish have moved away from shore. It's likely that we will only make it to one big spawning event in a season, and whatever the daily limit is will effectively be an annual limit.

I understand that some fishermen take a lot of herring, hundreds upon hundreds of pounds, sometimes filling trash cans and carting them back to their trucks. I've seen this and I don't care for it. But reducing the daily bag limit to just one bucket per person seems like a harsh overreaction. Granting a four-bucket limit would eliminate this problem while still allowing others to take home a reasonable amount of fish for the year.

This is a fish that people should be eating more of and the only way to get it is by catching it; the commercial herring fleet catches many times more herring than the recreational fishers and most of it does not get consumed by people, an atrocious waste of a resource.

Please consider a daily limit of four buckets.
Thanks very much.
Sincerely,
Andrew Bland

[redacted]

From: John Vogel [redacted]
Sent: Tuesday, July 23, 2019 9:47 AM
To: FGC
Subject: recreational herring limit

Follow Up Flag: Flag for follow up
Flag Status: Flagged

Hello,

I'm writing to express my concern that the proposed limit for recreational herring harvest is too low. This is a unique fishery where many people only have the opportunity to catch fish only once or twice a year. I understand the desire to prevent over harvesting, but I am not aware that there are a significant number of recreational fisherman who are harvesting huge quantities of herring for illicit commercial trade or waste. Thus, I feel that a limit of 5 5 gallon buckets would be reasonable and easily enforced. While I don't think that the vast majority of fisherman would not harvest this amount, it would give those who consume herring the opportunity to harvest enough for their needs.

Sincerely,

John Vogel

State of California
Department of Fish and Wildlife

Memorandum

Date: October 1, 2019

Orignial signed copy on file
Received on October 1, 2019

To: Melissa Miller-Henson
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Update and recommendations for possible adoption of the proposed rulemaking implementing the Pacific Herring Fishery Management Plan (Agenda item for the October 2019 Fish and Game Commission meeting)**

The Department of Fish and Wildlife (Department) has prepared this memorandum to summarize and provide responses to public comments received on the proposed addition of Section 28.62, Title 14, California Code of Regulations (CCR), and to describe necessary corrections to the proposed amendments to Sections 163.1 and 164, Title 14, CCR.

The Department has summarized and prepared responses to public comments received by the Fish and Game Commission on the proposed rulemaking. Several of these comments pertain to the Pacific Herring recreational bag limit and are addressed by the Department in Attachment 1. As explained in Attachment 1, the Department does not believe these comments warrant changes to the proposed rulemaking for Pacific Herring.

The Department is proposing a "no change" alternative in the Initial Statement of Reasons (ISOR) for subsection 163.1(d) and subsection 164(d)(1). Subsection 163.1(d) is corrected based on feedback received by the Department from commercial industry members and is proposed to retain the former language of the replaced regulations. The correction to 164(d)(1) fixes an inadvertent error in the proposed regulatory text and also reflects no change to the former language of the replaced regulations, as described in the ISOR. The Commission is given the option to select between the noticed alternative or the no change alternative identified below:

No change alternative 1 (Select either noticed alternative or no change alternative):

[Noticed alternative from 163.1(d)]

(d) Net Tending. Permitted vessels shall be in the immediate proximity, not exceeding one nautical mile, of any single gill net being fished.

[No change alternative – original text moved from 163(f)(2)(A)]

(d) Net Tending. Permitted vessels shall be in the immediate proximity, not exceeding three nautical miles, of any single gill net being fished.

No change alternative 2 (Select either noticed alternative or no change alternative):

[Noticed alternative]

(1) Not more than two (2) rafts; or two (2) lines; or one (1) raft and one (1) line may be used per permit.

[No change alternative – original text moved from 164(j)(1)]

(1) Not more than two (2) rafts and/or two (2) lines may be used per permit.

The Department recommends incorporating these two No Change Alternatives and adopting the proposed rulemaking for implementing the Pacific Herring Fishery Management Plan.

If you have any questions or need additional information regarding this item, please contact Department Environmental Scientist Andrew Weltz, at (707) 576-2896 or Andrew.Weltz@wildlife.ca.gov.

Enclosures:
Attachment 1

ec: Stafford Lehr, Deputy Director
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Attachment 1

Responses to Public Comment on the Herring FMP Rulemaking

Responses to comments received during the period of June 13 to September 11, 2019				
Commenter Number	**Commenter Name, Organization If Applicable**	**Draft Herring FMP Section or Proposed Title 14, CCR Section Referenced**	**Comment Summary**	**Response**
1	**Edward Zeng** Recreational Participant Email dated 6/18/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**1-a.** The Herring FMP proposes a daily limit of 100 lb. For reasons stated in email (missing spawn windows, health of Herring consumption, low gear requirement for recreational Herring take, low overall recreational catches), Mr. Zeng requests that the daily bag limit be raised to a minimum of 300 lbs.	There are not adequate data available to assess the magnitude of recreational Herring catches, so it is unknown if overall recreational Herring catches are low. The proposed daily limit of 100 lb was chosen to allow for a satisfying recreational experience for individuals while ensuring that total Herring harvest remains sustainable.
2	**Hua Bai** Recreational Participant Email dated 6/18/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**2-a.** Although a recreational limit is useful to prevent excess take, it is not practical to require recreational participants to have a scale that can weigh 100 lbs., as this requires purchase of extra equipment. An easier rule could be a big cooler full of Herring. Cooler can be sized so it is around 100lb to 200lb. This limit is easy to implement by all parties.	The proposed 100 lb upper limit of the range presented in the Herring FMP is expressed as equivalent to the volume of two 5-gallon buckets. These buckets are commonly owned pieces of equipment that allow participants and enforcement to assess compliance without having to weigh the Herring.
3	**Charlie Zhao** Recreational Participant Email dated 6/22/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**3-a.** Because recreational take depends on targeting an ongoing spawning event, this type of fishing is typically a once-per-year opportunity. Mr. Zhao typically tries to take an entire year's worth of fish in a single trip (roughly equal to two 27-gal containers from Costco, for one-gallon zip lock bag consumption daily for family all year). Even if people are commercializing recreational catch illegally, it does not affect ability of other recreational fishers to catch what they need. Mr. Zhao believes Herring are abundant, and that the commercial fishery takes much more, and has greater impact on population, than recreational take. There should not be a limit on rec take, and if there must be one, it should be set in volume for ease of measurement in field. Proposes 50 gallons as a reasonable limit if we must have one.	The proposed range of possession limits presented in the Herring FMP specifies both weight and volume of fish for ease of use by both participants and enforcement. This proposed limit is in line with the Department's goal of maintaining a satisfying recreational experience for participants. Recreational fishing limits are not intended to supply participants with a daily food source throughout the year.

3	**Charlie Zhao** (Continued)	FMP Section 7.8.7; Title 14, CCR §28.62	**3-b.** Setting a recreational limit on Herring disproportionately affects minorities because of much higher consumption of Herring among certain minority groups. As health care becomes more and more expensive and drags on the economy, Herring consumption should be encouraged instead of limited.	The Department is responsible for protecting the long-term sustainability of the Herring resource, to the extent possible, and to ensure that all of California's recreational participants can benefit from this resource for many years to come.
4	**Alastair Bland** Recreational Participant Email dated 7/4/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**4-a.** Concerned about proposal to limit recreational participants to two 5-gallon buckets or less per day. Four 5-gallon bucket (~150 lb) would be more reasonable than two buckets. A four-bucket limit would eliminate gross overtake, would remove incentive to illegally sell recreationally caught fish, would allow recreational participants to catch all that's needed for a year (share w/ family and friends) during a single spawn event. The Herring FMP's claim that recreational stakeholders expressed interest in 2-bucket limit misconstrues context of statement at 2018 Public Outreach meeting w/ stakeholders in Sausalito. Mr. Bland finds it personally offensive that commercial participants have called for tight limits on recreational catch, given that commercial fishery takes a far greater amount of Herring and sells for non-consumptive use, than recreational participants, who mostly eat their catch.	The proposed limit allows recreational participants to take up to 100 pounds (approximately 520 fish) per person per day. Families that would like to retain a greater number of fish are able to have more people participate in fishing. All comments at the 2018 Sausalito meeting were recorded in order to accurately capture stakeholder feedback.
4	**Alastair Bland** Second email dated 7/5/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**4-b.** Second comment letter further stressing that the Herring FMP's assertion that feedback from recreational sector informed proposed limit is essentially an overstatement.	Stakeholder feedback is an important part of the Herring FMP development process. All comments at the 2018 Sausalito meeting were recorded in order to accurately capture stakeholder feedback. Stakeholder support for the Department's proposed limit was expressed at this meeting and in follow up correspondence, in addition to some feedback that that the limit should be higher.
5	**John Vogel** Recreational Participant Email dated 7/23/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**5-a.** The proposed limit for recreational Herring harvest is too low. Recreational Herring is a unique fishery with opportunity to catch only once or twice a year. He understands the need to prevent over harvest, but is not aware of a significant number of recreational participants harvesting huge quantities	The proposed upper limit for recreational take would allow participants to take up to 100 pounds (approximately 520 fish) per person. Families that would like to maximize the amount of fish they take legally may choose to have more family members participate in fishing. While the Department

			for illicit commercialization or waste. Wants a five 5-gallon buckets as a limit.	understands that, due to the pulse nature of spawning events, there may be limited fishing opportunities in a season, this limit is designed to balance providing a satisfying recreational experience with the needs of the resource.
6	**Bradley S. Cain** Recreational Fisherman Email dated 7/24/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**6-a.** Displeased with 1 bucket limit for recreational take of Herring. 4 or 5-bucket limit is more reasonable. Spawning is unpredictable in nature and it is difficult for rec fishers to get to an active spawning event. Sometimes miss spawns entirely. When a decent spawn event can be effectively targeted, currently take enough to stock freezer for entire year's use (consumption and bait). One bucket would not allow this as it wouldn't last a year. Additionally, 1 bucket limit is overly restrictive given volume of commercial catch annually. Rec fishers do not impact fishery, unlike commercial. Please reconsider and adopt a limit of no less than 4 buckets per day.	The proposed limit for the recreational Herring fishery is not designed to supply participants with a year-long supply of either bait or daily food. The goal of this limit is to sustainably manage the resource, which can experience intense recreational fishing pressure during nearshore spawning events, while allowing fishers a satisfying recreational experience. The proposed limit takes into consideration the needs of the Pacific Herring resource as well as that of both the commercial and recreational sectors.
7	**Kirk Lombard** Recreational Participant, Blogger and Author, Fishmonger Email dated 7/24/2019	FMP Section 7.8.7; Title 14, CCR §28.62	**7-a.** The proposed recreational limit range goes too far. Supports limits in general. A zero-bucket limit is an overreaction. Makes six points about recreational take of Herring, including limited number of days they are accessible from shore, and that most people only take a few buckets during spawns (problem of over harvest stems from a few bad apples). Mr. Lombard contrasts recreational take with commercial gillnet take (recreationally-caught fish are eaten locally, gillnet catch is exported) emphasizing local benefit of recreational take and poor quality of gillnet-acquired fish for eating. He points out high utilization by Asian Americans and high level of complaint from non-Asian Americans and commercial fishermen. Mr. Lombard suggests that one bucket only seems like a large quantity to individuals who do not fish for Herring, since a single bucket only lasts 3 months, and emphasizes the healthy aspects of eating low-on-the-food chain species caught locally.	While the Department understands that Herring are only available during a few nearshore spawning events, those events can experience intensive recreational pressure, with hundreds of participants targeting Herring. The proposed limit is designed to allow participants a satisfying recreational experience while limiting the impacts of harvest on the schools that spawn in these nearshore areas.

6	**Kirk Lombard** (Continued)	FMP Section 7.8.7; Title 14, CCR §28.62	**7-b.** Prefers for the lower end of recreational Herring limit range be two 5-gallon buckets, if not 3-4.	The 0-lb lower limit to the Herring FMP's recommended range allows for closure of the recreational fishery without an amendment should conditions in the future require such a closure.
8	**Russell Johnston** Marine Science Institute, UC Santa Barbara Email dated 7/25/2019	FMP General	**8-a.** General support for adoption pending specific listed changes.	The Department appreciates support for the Herring FMP. It has responded to comments received as appropriate.
8	**Russell Johnston** (Continued)	FMP Appendices	**8-b.** Provide all appendices as part of FMP and organize so as to be readily navigated by the public.	Appropriate page numbering has been applied and all appendices are included in in the Final Herring FMP. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.
8	**Russell Johnston** (Continued)	FMP Section 2.13.2.3, Appendix D	**8-c.** Include Humboldt Bay spawn areas in maps of spawn areas depicted in Chapter 2 and Appendix D.	Habitat maps for management areas where no commercial activity occurs at the time of Herring FMP development are presented in Appendix D. However, the Humboldt Bay map in the Draft Herring FMP Appendix D did not include spawn areas. Detailed maps of recent observed spawning locations are available for Humboldt Bay and have been be included in the Final Herring FMP. Section 2.13.2.3 has been edited to refer the reader to Appendix D for Humboldt Bay spawn areas.
8	**Russell Johnston** (Continued)	FMP Executive Summary, General	**8-d.** Present all FMP goals equally, including compliance with forage species policy and incorporation of ecosystem indicators.	The primary management goals outlined in the Herring FMP are those described in the MLMA, which provides the legal framework for fisheries management in California. For this reason, these goals are given primacy in the Herring FMP. However, the Commission's forage species policy also played an important role in the development of the FMP objectives, as described in the Herring FMP.

9	**Nick Sohrakoff** Commercial Participant, Director's Herring Advisory Committee President, FMP Steering Committee Member Email dated 7/29/2019	FMP Section 4.7.2	**9-a.** The SFBHRA (San Francisco Bay Herring Research Association) did not file a lawsuit. The lawsuit in referenced was filed by the SFHA (San Francisco Herring Association). Please correct the draft changing SFBHRA to SFHA to reflect the proper entity that filed the lawsuit.	This error has been corrected in the Final Herring FMP.
9	**Nick Sohrakoff** Oral Comment w/ Anna W. (Commenter 10) at FGC Meeting 8/8/2019	FMP General	**9-b.** General expression of support – DHAC supported FMP 12 years ago, SC was a successful collaborative effort, would like to fund a genetic study with Audubon for stocks in CA and southern Oregon.	The Herring FMP was the result of a great deal of work by many different stakeholders, and the Department hopes to continue future collaborations to benefit the resource.
10	**Geoff Shester**, Oceana and FMP Steering Committee; **Anna Weinstein**, Audubon California and FMP Steering Committee; **Irene Gutierrez**, NRDC; **Greg Helms**, Ocean Conservancy;	FMP Appendices	**10-a.** Appendix R is currently missing from the FMP due to an error. Based on an agreement by the Steering Committee, this Appendix was intended to describe an increased range of catch limit adjustments resulting from ecosystem considerations that the Department may use as scientific information improves, without an FMP amendment. We request that Appendix R be included in the FMP and that the public be afforded the opportunity to review and provide comments on its contents prior to final adoption of the FMP.	Appendix R was drafted, but omitted from the Draft Herring FMP in error. Appendix R was included in an updated Draft FMP that was made available for public viewing and comment, and is included in the Final Herring FMP. Appendix R contains information on the development of the Harvest Control Rule framework, as well as guidance for amending the decision tree as the field of ecosystem-based fishery management develops. Any increase in the bounds on ecosystem-based quota adjustment beyond those indicated in Chapter 7 (Figure 7-3) and Appendix R (Figure R-3) will require an amendment.

	Andrea Treece, Earthjustice; **Paul Shively**, Pew Charitable Trusts Letter dated 7/25/2019 **(NGO Letter)**			
10	**NGO Letter** (Continued)	FMP Section 7.5.3	**10-b.** We request the FMP include clear, objective criteria for determining whether a Tier 2 stock is overfished and clarify what the rebuilding provisions are for overfished Tier 2 stocks. The MLMA requires that FMPs must specify criteria for identifying when a stock is overfished, include measures to end or prevent overfishing, and provide a mechanism for rebuilding in the shortest time period possible (FGC §7086). While the draft FMP identifies criteria for determining whether the San Francisco Bay stock is overfished as well as rebuilding provisions (Section 7.8.1), it does not contain criteria for determining whether any of the stocks outside San Francisco Bay stocks would be considered overfished when they are in Tier 2. It also does not specify how the San Francisco Bay stock would be considered overfished if it is moved to Tier 2 status in the future. The FMP does not provide objective criteria for what constitutes "very poor spawning behavior" or "an SSB too small to support fishing." For example, this could be remedied by clarifying how "low" or "very poor spawning behavior" is determined in the Rapid Spawn Assessments for Tier 2 stocks and stating in the FMP that this is the criteria for overfished.	Section 7.5.3 has been amended in the Final Herring FMP to include specific criteria for determining when a given management area's spawning stock biomass is considered overfished or otherwise depressed under Tier 2. If the stocks drop below these respective limits, the quotas will be set to zero to promote stock rebuilding. This brings the management plan into compliance with the MLMA, which states that FMPs must specify overfishing limits and rebuilding plans.
10	**NGO Letter** (Continued)	FMP Appendices	**10-c.** The number and size of the Appendices substantially increase the size of the overall FMP document, which as presented, will complicate navigation of the FMP by the public. While each Appendix provides important information and is referenced in the body of the FMP, we suggest the Appendices be available as separate documents from the main body of the FMP, and that each	Appropriate page numbering has been applied to all appendices in the Final Herring FMP. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.

			Appendix contain consistent page numbering and formatting to improve navigation of the FMP.	
10	**NGO Letter** (Continued)	FMP General	**10-d.** Throughout the document, the term "quota" is used when referring to the annual catch limit. The term quota is problematic because in other contexts "quota" may refer to a minimum quantity or goal, rather than a maximum limit. To maintain consistency and clarity for the public, we request the FMP not use the term "quota" and instead use the term "catch limit."	The term "quota" is frequently used interchangeably with "catch limit" in fisheries management. In addition, the Marine Life Management Act uses the term "quota" rather than "catch limit" in specifying the types of conservation and management measures that should be described in an FMP (Section 7802(c)). Furthermore, the term quota has been used historically in documents related to management of California's Pacific Herring fishery. For consistency with these documents, the Final FMP retains use of the word "quota".
10	**NGO Letter** (Continued)	FMP Section 2.13.2.2, Appendix D	**10-e.** In Section 2.13.2.3 (p. 2-26), the Department's maps of Herring spawning areal extent and most-used spawning areas for Humboldt Bay should be included, in the manner San Francisco Bay's maps appear in that section. Also, these updated maps should be put into the Habitat section (pg. 319).	Habitat maps for management areas where no commercial activity occurs at the time of FMP development are presented in Appendix D. However, the Humboldt Bay map in the Draft FMP Appendix D did not include spawn areas. Detailed maps of recent observed spawning locations are available for Humboldt Bay and have been be included in the Final FMP. Section 2.13.2.3 has been edited to refer the reader to Appendix D for Humboldt Bay spawn areas.
10	**NGO Letter** (Continued)	FMP Section 7.7.2	**10-f.** The Executive Summary (p. ii) and Section 7.7.2 state that complying with the Commission's Forage Species policy is a secondary goal. This prioritization undercuts the Commission's forage policy and implies that other goals are more important. We request that the FMP present all goals equally, including compliance with the Forage Species policy and incorporating ecosystem considerations into Herring management.	The primary management goals as outlined in the Herring FMP are those described in the MLMA, which is the overarching legal framework for fisheries management in California. For this reason, these goals are given primacy in the Herring FMP. However, the Commission's forage species policy played an important role in the development of FMP objectives, as described in the Herring FMP.
10	**NGO Letter** (Continued)	FMP Executive Summary, Section 7.6.3	**10-g.** The Executive Summary (p. iv) indicates that the multi-indicator predictive model is adopted by the FMP. However, Section 7.6.3 makes clear that the spawn deposition surveys are the default for estimating San Francisco Bay SSB until the predictive model has 3 or more years of successful predictive power. The Executive Summary should be clarified consistent with this description in Section 7.6.3.	The Herring FMP adopts the multi-indicator predictive model as an option for estimating Spawning Stock Biomass in the San Francisco Bay management area. The Final Herring FMP Section 7.6.3 has been edited to clarify the requirements for use of the multi-indicator predictive model. Spawn deposition surveys remain the default method for determining Spawning Stock Biomass, and the Executive Summary has been edited to clarify this.

10	**NGO Letter** (Continued)	FMP Section 7.7.1, Figure 7-2; Appendix F	**10-h.** The FMP should clarify that Figure 7-2 represents the default harvest control rule, which is subject to ecosystem adjustments as indicated by the decision tree. Currently, Appendix F and Figure 7-2 are misleading because they do not reference potential adjustments to catch limits based on ecosystem considerations, therefore implying that these represent the final catch limit.	Chapter 7 has been modified so that the caption for Figure 7-2 clarifies that the black line indicates the unadjusted quota for the season. Section 7.7 describes how the quota may be adjusted for ecosystem considerations.
10	**NGO Letter** (Continued)	FMP Executive Summary	**10-i.** Given California's leading role in addressing the climate crisis, the Executive Summary should emphasize and highlight the several areas where climate change is addressed in the FMP, specifically the use of climate indicators in the predictive model, the use of management strategy evaluation to ensure the harvest control rule is robust to future climate change scenarios, and the use of climate indicators as ecosystem considerations.	Adaptive management frameworks based on the best available science and including multiple indicators, such as the framework presented in the Herring FMP, are key tools for promoting climate change resilience in fisheries management, and this is emphasized throughout the document. The Executive Summary has been updated in the Final Herring FMP to better reflect this.
10	**NGO Letter** (Continued)	FMP Acknowledge-ments	**10-j.** Finally, we request that the Acknowledgments section recognize all cash funding sources for the FMP, specifically the Gordon and Betty Moore Foundation and the National Fish and Wildlife Foundation.	The Gordon and Betty Moore Foundation has been added to the Acknowledgements in the Final Herring FMP.
10	**NGO Letter** (Continued)	FMP General	**10-k.** For the [several stated] reasons, we support the adoption of the FMP. We request the Commission incorporate the above recommendations on the Draft Herring FMP into the final version and urge the Commission to adopt the Final Herring FMP at its October meeting, as scheduled.	Support for the Herring FMP is appreciated. Comments received have been responded to here and in the Final FMP as appropriate.
11	**Anna Weinstein** Audubon California Herring FMP Steering Committee	FMP General	**11-a.** [Signatories and Audubon] support the adoption of the Fishery Management Plan (FMP) for Pacific Herring at your meeting in October 2019, pending specific changes listed.	Support for the Herring FMP is appreciated. Comments received have been responded to here and in the Final FMP as appropriate.

	+3,258 Individual Signatories Letter dated 7/31/2019			
11	**Anna Weinstein +3,258 Individual Signatories** (Continued)	FMP Appendices	**11-b.** All the Appendices are provided as part of the FMP and organized so they can be readily navigated by the public.	All appendices, including Appendix R (see response to Comment **9-a**), are now available for the public to review, and include appropriate page numbering. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.
11	**Anna Weinstein +3,258 Individual Signatories** (Continued)	FMP Section 2.13.2.3, Appendix D	**11-c.** The Department's maps of Herring spawning areal extent and most-used spawning areas for Humboldt Bay should be included in the FMP.	Habitat maps for management areas where no commercial activity occurs at the time of Herring FMP development are presented in Appendix D. However, the Humboldt Bay map in the Draft Herring FMP Appendix D did not include spawn areas. Detailed maps of recent observed spawning locations are available for Humboldt Bay and have been be included in the Final FMP. Section 2.13.2.3 has been edited to refer the reader to Appendix D for Humboldt Bay spawn areas.
11	**Anna Weinstein +3,258 Individual Signatories** (Continued)	FMP Executive Summary	**11-d.** In the Executive Summary and throughout the FMP, present all FMP goals equally, including compliance with the forage species policy and incorporating ecosystem considerations into Herring management.	The primary management goals as outlined in the FMP are those described in the MLMA, which is the overarching legal framework for fisheries management in California. For this reason, these goals are given primacy in the Herring FMP. However, the Commission's forage species policy played an important role in the development of the FMP objectives, as described in the FMP.
11	**Anna Weinstein** Oral comment w/ Nick S. (Commenter 8) at FGC meeting 8/8/2019	FMP General	**11-e.** General support. Commend and thank involved parties, including FGC. FMP is groundbreaking.	Support for the Herring FMP is appreciated.

11	**Anna Weinstein** Oral comment w/ Nick S. (Continued)	FMP General	**11-f.** Audubon has provided comment and non-substantive requests to ensure transparency and MLMA compliance (formatting fixes, better assembled appendices on website, tier 2 fishery criteria).	Comments received have been responded to here and in the Final FMP as appropriate.
12	**Nils Warnock** Audubon Canyon Ranch (ACR) Letter dated 7/31/2019	FMP Section 7.8.2.2	**12-a.** ACR agrees with the Commission's recommendation to reduce the maximum number of permits allowed for Tomales Bay (from 35 to 15 via attrition), but further recommends that no new permits be issued for Tomales Bay (instead of beginning to issue once number of Tomales permits drops below 15). Rather, Tomales Bay would be best left as a protected area for Herring. Cites linked importance of Herring to seabirds, lack of commercial interest in Tomales Bay Fishery, and proximity to SF bay fishery as reasons.	The FMP specifies a management approach for Pacific Herring in Tomales Bay that is compatible with both conservation and fishing goals. Should there be renewed commercial interest in Herring fishing in Tomales Bay, the quota will be set at a small fraction of historical quotas to ensure that the Tomales Bay Herring stock can serve as food for predators as well as support a small commercial fishery, as described in Chapter 7.
12	**Nils Warnock** (Continued)	FMP Section 7.8.7	**12-b.** ACR endorses FMP's recommendation of a recreational bag limit range of 0-100 lbs, equivalent to up to ten gallons, or two 5-gallon buckets of Herring, each containing 260 fish.	Support for the Herring FMP's recreational bag limit is appreciated.
12	**Nils Warnock** (Continued)	FMP Chapter 7 - Tomales Bay Spawning Biomass Surveys	**12-c.** As current monitoring data are critical for helping managers steward resources, especially during these times of rapid climate change, ACR encourages the Commission to recommend renewed Herring monitoring in Tomales Bay.	The Herring FMP identifies management areas with active commercial fisheries as the highest priority for monitoring. As described in Chapter 7, an appropriate level of monitoring will resume in Tomales Bay should commercial fishing activity resume there.
12	**Nils Warnock** (Continued)	FMP General	**12-d.** With some suggested modifications, Herring FMP will provide strong guidance for the long-term sustainable mgmt. of Pacific Herring in California, including Tomales Bay.	Support for the Herring FMP is appreciated. Comments received have been responded to here and in the Final FMP as appropriate.
13	**Pam Young** Golden Gate Audubon Society Letter dated 7/31/2019	FMP General	**13-a.** General support for the Herring FMP, including use of the best available science to support sustainable management.	Support for the Herring FMP is appreciated.

14	**Morgan Patton**, West Marin Environmental Action Committee (EAC); **Ashley Eagle-Gibbs**, EAC Letter dated 8/1/2019	FMP Section 7.8.7	**14-a.** Consistent with past comments and Audubon Canyon Ranch's comments, EAC supports the Herring FMP's daily bag limit two 5-gallon buckets of Pacific Herring	Support for the Herring FMP's recreational bag limit is appreciated.
14	**Morgan Patton, Ashley Eagle Gibbs** (Continued)	FMP Chapter 7, General	**14-b.** While supportive of the overall management strategy in Chapter 7 of the Herring FMP, recommend full closure of commercial fishery in Tomales Bay, due to a number of factors. These include low Herring numbers, environmental considerations, lack of interest, high operating costs, and poor market conditions. No recent research (other than observations) has been conducted to indicate adequate biomass for the Tomales Bay fishery operation. Recommend CDFW (or other qualified and independent researchers) conduct renewed monitoring of Herring populations in Tomales Bay in order to compare against outdated information that is now 13 years old [limited monitoring conducted during 2006-07 season] to better understand the population dynamics	Support for the Herring FMP's management strategy is appreciated. The Herring FMP specifies a management approach for Pacific Herring in Tomales Bay that is compatible with both conservation and fishing goals. As described in Chapter 7, a precautionary quota is available, and an appropriate level of monitoring shall occur should commercial interest in the Tomales Bay stock resume.
14	**Morgan Patton, Ashley Eagle Gibbs** (Continued)	FMP Chapter 7, General	**14-c.** The Tomales Bay Herring fishery should only be open after a comprehensive and scientifically based assessment and analysis is made of the Herring stocks, current and future spawning estimates, biomass, etc. led by Department of Fish and Wildlife staff and/or other trained and independent researchers, with the involvement of multiple stakeholders. EAC requests that these opportunities are truly collaborative and include stakeholders representative of multiple interests including local West Marin fisherman, individuals	Should there be renewed commercial interest in Herring fishing in Tomales Bay, the Herring FMP specifies that the quota will be set at precautionary harvest rate to ensure that the Tomales Bay Herring stock can fulfill its ecological role as forage for predators as well as support a small fishery. This harvest rate can only be increased with additional monitoring demonstrating the population can support additional harvest, including determination of the Spawning Stock Biomass. The Department welcomes the opportunity to collaborate with

			from non-extractive industries, and environmental organizations.	stakeholders to increase our collective understanding of California's Pacific Herring stocks.
15	**Julie Thayer, Ph.D.** Farallon Institute Letter dated 7/31/2019 in attachment to Email dated 8/1/2019	FMP Chapters 3, 7; Appendices E, F	**15-a.** Work conducted by the Farallon institute as a contractor on FMP development was not accurately represented in the draft FMP. Includes specific description of issues with information presented in Ch 3, Ch 7, and Appendix E, and F. Inaccurate representation of this work led to erroneous conclusions by Peer Review of FMP science. Requests that actual contractor work be presented in the appendices.	The Farallon Institute was subcontracted to assist the Project Management Team with developing scientific advice for the management of Pacific Herring. This work produced a number of valuable contributions to the field of ecosystem-based fishery management, and the parts that were used in the development of the FMP's management framework were provided to the Peer Review, are reproduced in Appendices E and F. However, there were other components of the work produced that were evaluated by the Project Management Team, the Department, and the Steering Committee that were deemed to be not suitable for use in the management framework at this time. The Peer Review committee requested to see, and were provided, additional components from the Farallon Institute's work that were not used in the Herring FMP during the review process. As such, the review committee's final recommendation does take into account these additional components as well.
15	**Julie Thayer, Ph.D.** (Continued)	FMP Chapter 7, Section 7.6.3	**15-b.** Chapter 7 incorrectly states that the predictive model needs to be tested before use, though it has already been validated against 27 years of SF Bay biomass.	The Herring FMP adopts the multi-indicator predicted model as an option for estimating Spawning Stock Biomass in the San Francisco Bay management area. The Final Herring FMP Section 7.6.3 has been edited to clarify the requirements for use of the multi-indicator predictive model. Specifically, the model's use depends on availability of required data and its continued predictive skill.
15	**Julie Thayer, Ph.D.** (Continued)	FMP Appendix E	**15-c.** Appendix E summarizes a draft report of the SSB forecasting model submitted by Farallon Institute early in the FMP development process, instead of the final publication of this work which included key revisions to the original draft	The information summarized in appendices E and F includes the portions of the work produced by the Farallon Institute under subcontract by the Project Management Team that were included in the Herring FMP. The final publication referred to (Sydeman and others, 2018) does not include the multi-indicator predictive model adopted by the Herring FMP.

				However, this publication is referenced in the FMP, including in Appendix E, as appropriate.
15	**Julie Thayer, Ph.D.** (Continued)	FMP Chapter 9, Appendix R	**15-d.** Considerations for future research and management should include the importance of making ecosystem-based catch adjustments more meaningful. Re-instate appendix R, allow wider discretion on quota adjustment bounds in HCR framework.	Appendix R was drafted, but omitted from the May-dated Draft FMP in error (see response to Comment **9-a**). It has been included in the Final FMP and contains information on the development of the Harvest Control Rule framework, as well as guidance for amending the Decision Tree as the field of ecosystem-based fishery management develops. Any increase in the bounds on ecosystem-based quota adjustment beyond those indicated in Chapter 7 (Figure 7-3) and Appendix R (Figure R-3) will require FMP amendment.
15	**Julie Thayer, Ph.D.** (Continued)	FMP Sections 2.4, 5.6, Chapter 8	**15-e.** Importance of temporal variability in spawning should be explicitly stated in the FMP (w/ specific recommendations for Sections 2.4, 5.6, and Chapter 8).	The observed temporal variability in Herring spawning is stated a number of times throughout the Herring FMP. In particular, Section 2.4 and Figure 2-4 describe the available information on this variability. Section 8.6 also flags changes in observed spawning habitat over time as a key uncertainty and avenue for future research.
15	**Julie Thayer, Ph.D.** (Continued)	FMP Appendices	**15-f.** The FMP is prohibitively large and difficult to navigate due to myriad of appendices, both current and historical information. Suggest final document only include immediately-relevant supplemental material such as formulas and decision trees, w/ clear page numbering. Historical info should be separated into distinct files that can be downloaded separately, and are also clearly referenced.	California's Herring fishery is complex, with a long history of management. The FMP serves as a central repository for all of the available information on Pacific Herring and its management in California. Pending adoption, for ease of download, the FMP body and appendices will be made available separately.
16	**Jennifer Fearing** Fearless Advocacy Oral comment at FGC meeting 8/8/2019	FMP General	**16-a.** Strong support for adoption in October. The FMP is a tremendous step forward for Ecosystem-Based Management. Appreciate CDFW incorporating appendix R	Support for the Herring FMP is appreciated. Appendix R was drafted but was omitted in error (see response to Comment **9-a**). It has been included in an updated draft of the FMP and is available for review.

16	**Jennifer Fearing** (Continued)	FMP Section 7.5.3	**16-b.** As per NGO Letter (see Commenter 9), recommendations to strengthen MLMA compliance w/out altering timeline for adoption, request Fish and Game Commission direct CDFW to address those recommendations prior to adoption.	Section 7.5.3 has been amended in the Final Herring FMP to include criteria for determining when a given management area's spawning stock biomass is considered overfished or otherwise depressed under Tier 2. If the stocks drops below these limits, the quotas will be set to zero to promote stock rebuilding. This brings the management plan into compliance with the MLMA, which states that FMPs must specify overfishing limits and rebuilding plans.

Proposed Regulations to Implement the Pacific Herring Fishery Management Plan

Adoption Hearing

Fish and Game Commission Meeting
Valley Center, CA
October 10, 2019

Dr. Craig Shuman
Marine Regional Manager
California Department of Fish and Wildlife

CDFW photo

Review of Timeline

- June 2019
  - Notice ISOR for Regulatory Action
- August 2019
  - Discussion hearing
- October 2019
  - Adoption hearing


CDFW photo

Overview of Proposed Regs.

- Implement Herring FMP
- Establish a recreational bag limit
- Regulate commercial fishery under the Herring FMP

Recreational Regulations

Proposed Recreational Bag Limit

- Proposed range (0 -100 lbs) established by the Herring FMP
- Dept. recommendation is in the middle of the range
- Sustainable management, balanced with a satisfying sport experience

CDFW photo

Thank you

For more information please contact:

Andrew Weltz
Environmental Scientist
Marine Region, Department of fish and Wildlife
Andrew.Weltz@wildlife.ca.gov

CDFW photo

DRAFT DOCUMENT

Print Form

Notice of Exemption

Appendix E

To: Office of Planning and Research
P.O. Box 3044, Room 113
Sacramento, CA 95812-3044

County Clerk
County of: N/A

From: (Public Agency): California Fish and Game Commission
1416 Ninth Street, Suite 1320
Sacramento, CA 95614
(Address)

Project Title: California Pacific Herring Fishery Management Plan Implementing Regulations

Project Applicant: N/A

Project Location - Specific:

San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City

Project Location - City: San Francisco, Tomales, Humboldt, and Crescent City Project Location - County: Napa County, Marin County, Humboldt County and Del Norte County

Description of Nature, Purpose and Beneficiaries of Project:

Adoption of the herring fishery management plan implementing regulations.

Name of Public Agency Approving Project: California Department of Fish and Wildlife

Name of Person or Agency Carrying Out Project: California Department of Fish and Wildlife

Exempt Status: **(check one):**

- ☐ Ministerial (Sec. 21080(b)(1); 15268);
- ☐ Declared Emergency (Sec. 21080(b)(3); 15269(a));
- ☐ Emergency Project (Sec. 21080(b)(4); 15269(b)(c));
- ☐ Categorical Exemption. State type and section number: ____
- ■ Statutory Exemptions. State code number: Fish and Game Code s. 7078(e)

Reasons why project is exempt:

The Fish and Game Commission adopted the Herring FMP on October 9th prior to approving this project. The regulations that constitute this project are regulations implementing that FMP and thus explicitly fit within the referenced statute.

Lead Agency Contact Person: Melissa Miller-Henson Area Code/Telephone/Extension: (916) 653-4899

If filed by applicant:

1. Attach certified document of exemption finding.
2. Has a Notice of Exemption been filed by the public agency approving the project? ☐ Yes ☐ No

Signature: ____ Date: ____ Title: ____

☐ Signed by Lead Agency ☐ Signed by Applicant

Authority cited: Sections 21083 and 21110, Public Resources Code.
Reference: Sections 21108, 21152, and 21152.1, Public Resources Code.

Date Received for filing at OPR: ____

RECEIVED
CALIFORNIA
FISH AND GAME
COMMISSION

2019 [illegible]

Malibu Oyster Company

April 17th 2019
California Fish and Game Commission

California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

Dear Fish and Game Commission:

Please find enclosed two copies of Malibu Oyster Companies application for lease of State water bottoms and a check for the $500 application fee.

Thank you for your consideration of our application! We look forward to hearing from you.

Signature: ______________________

Signature: ______________________

J.P. Garofalo & Nick Mercer
Co – Founders Malibu Oyster Company

Date 4/17/2019

PAY to the order of California Fish and Game Commission $ 500.00

Five Hundred xx/100 Dollars

Security Features Details on Back.

For State Water Bottomlease App

MP

Date 4/17/2019

PAY to the order of California Fish and Game Commission $ 500.00

Five Hundred xx/100 Dollars

Security Features Details on Back.

For State Water Bottom Lease App

MP

DEPARTMENT OF FISH AND WILDLIFE

DEPARTMENT OF FISH AND WILDLIFE

Valeriya Kryuchkov
4/22/19

Project Proposal & Business Plan

Prepared by J.P. Garofalo & Nick Mercer
April 2019

FORM A

State of California Fish and Game Commission Application for Lease of State Water Bottoms for Aquaculture

Applicant Name: Malibu Oyster Company **Phone:** (203) 856-1275 / (310) 339-9114

Address: 902 Washington Avenue, Unit C, Santa Monica, CA 90403

Aquaculture Registration No. To Be Determined **Expiration Date**: To Be Determined

Species of plant or animals to be cultured:

- Crassostrea gigas ("Pacific oyster") (Triploid seed only)
- Ostrea lurida ("Olympia oyster")
- Laminaria saccharina ("Sugar kelp")
- Crassostrea sikamea ("Kumamoto oyster")
- Crassadoma gigantea ("Giant rock scallop")
- Macrocystis pyrifera ("Giant kelp")
- Mesocentrotus franciscanus ("Red Sea Urchin")

Application is hereby made to the Fish and Game Commission of the State of California for a lease of State water bottoms in the area described in the attached exhibit entitled "Exhibit A-Legal Description," and as shown on the map attached hereto marked "Exhibit B." Each exhibit bears the name of this applicant. Such lease will be for the purpose of aquaculture involving the species designated above. In support of this application, the applicant hereby submits the following explanation of the type of operation and cultural practices to be employed:

A. Purpose of operation - Production
B. Plan of development and proposed production schedule – 5-year plan
C. Type of cultural method(s) to be employed: long line with buoyed habitats, etc.
D. Department of Health Services growing water classification: Unclassified

(Please see additional sheets for detailed explanation)

Date: 4/17/2019

Print Name: J.P. Garofalo and Nick Mercer on behalf of Malibu Oyster Company

Signed: [signatures]

Introduction & Background

Company Introduction:

The Malibu Oyster Company ("The Company" or "MOC"), a Delaware Corporation, was formed in June of 2018 with the intent of pursuing a California state bottom lease for growing premium oysters for the half shell market, as well as fresh kelp for consumption. The Company plans to provide locally-sourced and sustainably farmed products directly to the sprawling Greater Los Angeles area. Locally cultivated seafood will not only help meet growing demand in the market, but also serve as a source of economic opportunity and employment for the community. Additionally, MOC is a mission-driven company dedicated to promoting a sustainable aquaculture industry in Southern California that supports a regenerative symbiotic relationship with the ocean.

Applicant(s):

J.P. Garofalo

J.P. Garofalo, co-founder of Malibu Oyster Company, grew up in the western part of Connecticut where oyster farming was a constant feature of the landscape. In his teenage years, he spent the summers working on a local oyster farm during its infancy and facilitated the development of their early cultivation methodologies and record-keeping policies. Following graduation from Middlebury College, Mr. Garofalo has worked in the financial services industry. After working in New York for 5 years, he moved to Los Angeles where he works at Ares Management, a leading global private equity firm. His passion for aquaculture and sustainable farming has persisted since his days on the Long Island Sound. With his background in oyster farming and cultivation, Mr. Garofalo will be primarily responsible for the Company's farming operations.

Nick Mercer

Nick Mercer, co-founder of Malibu Oyster Company, is a native Californian and grew up just a few miles from the proposed farm location. He graduated from Connecticut College in 2010 with a degree in Anthropology and moved to NYC to pursue a career in the media industry. Nick moved back to Los Angeles 3 years ago to run west coast sales for Parse.ly, a media analytics company, and has had the privilege to work with Disney, the NFL and Amazon. As an avid aquaculture enthusiast and environmentalist, Nick has always been personally interested in the sustainability of seafood. With a strong sales and marketing background Nick will oversee distribution for MOC.

The Malibu Oyster Company is working alongside GreenWave, a pioneering nonprofit organization dedicated to building a new blue-green economy that creates jobs, mitigates climate change and grows healthy food for local communities. As a farmer and fisherman run organization, GreenWave provides expertise, training and guidance for new farmers in their regenerative polyculture farming program. MOC is working in partnership with GreenWave and thus far has worked with Karen Gray, the California Reef Manager, to advance our site selection and bottom lease process in California. Through this strong working relationship, MOC will leverage access to industry experts across the country and within the state of California to gain insights into best management practices, operations, cultural methodologies and technical implementation. The Company will plan to appoint members of the GreenWave team to a Board of Advisors along with other local specialists, industry cohorts, and local University academics and research specialists.

Project Summary:

The Malibu Oyster Company will launch a commercial offshore aquaculture operation based in Los Angeles County. The site will be located in California state waters approximately one mile offshore of Malibu Lagoon and will encompass ~100 acres. Production will primarily consist of Pacific oysters and Sugar kelp and will be landed in the Marina del Rey Harbor. Cultivation methods will be via surface-level floating cages secured on longlines and anchored to the ocean floor. Kelp will be cultivated on the longlines connecting each floating cage with approximately 8-10 feet between each cage and 10 cages to a longline.

MOC plans to predominately purchase triploid oyster seed or "spat" at 12mm and deploy them in 6mm mesh bags within floating cages. As available, triploid seed will be sourced from San Diego Bay Aquaculture, Northern California as available from Hog Island Oyster Company, Hawaii via the Taylor Shellfish Facility or Goose Point Oysters facilities, and/or Washington State hatcheries such as Whiskey Creek. Any spat sourced will be certified and approved by the California Department of Fish and Wildlife ("CDFW"). In the first 1-2 years of operation, kelp seed will be supplied in partnership with GreenWave as a member of their support network. The Company will seek to source seed from other local sources within California, such as PharmerSea, as well as begin our own small-scale kelp hatchery.

Sorting and tumbling of oysters will occur every 6 – 8 weeks as necessary and dependent on growing conditions. Due to the distance to port, oysters will be hauled onboard the working vessel and tumbled and sorted onsite. Oysters of market size will be culled, graded, cleaned and bagged for harvest and distribution. Kelp will be planted annually in the fall and harvested in the spring. Notably, kelp will only be cut and harvested if it is directly attached to the longlines. Any other marine algae not directly attached to the longline as initially planted will be considered biofoul and will be released accordingly.

Operation and Cultural Practices

Purpose of Operation:

Malibu Oyster Company's primary purpose of operation is for the production, cultivation, harvest, distribution and direct sale of Pacific oysters (Crassostrea gigas) and Sugar kelp (Laminaria saccharina). In doing so, the Company will be providing a much-needed source of locally-grown seafood to a large economic community through sustainable and regenerative aquaculture practices in Los Angeles County.

Site Selection, Plan of Development and Proposed Production Schedule:

Site Selection:

The proposed site (please see Exhibit A) is approximately 100 acres in size, is in California state waters, is not located in commercial shipping lanes, a marine reserve or conservation area, Halibut Trawling Grounds or an Area of Special Biological Significance, and is within a closed Kelp Bed Boundary with precedent for obtaining a bottom lease and does not conflict with aquaculture activity on state leased parcels.

Further to the Company's site selection process, the proposed site is a judicious and iterative choice given the legal limitations outlined by the California Department of Fish and Wildlife, California Coastal Commission as well as guidance provided by the California Department of Health and considerations regarding recreation within the greater Los Angeles area. To the north in areas serviceable from Ventura Harbor, proposed site locations conflict with existing Halibut Trawling Grounds. From Laguna Point/Point Mugu to Point Dume, the area is zoned as a leasable Kelp Bed Boundary. Upon consultation with CDFW, they determined that the Company, as an owner of an aquaculture lease, would be in conflict with any potential lessee of the Kelp Bed Boundary. Within the western portion of Malibu, state waters consist of the Point Dume State Marine Reserve and Conservation area, as well as another leasable Kelp Bed Boundary (zone 16) [Exhibit C]. Looking to the south of the proposed location towards the Santa Monica Basin, the project would begin to conflict with greater volumes of recreational boaters and fisherman out of Marina del Rey and Redondo harbors. Moreover, storm drains and runoff located directly within the Santa Monica basin provide further concern for consistently diminished water quality. In contrast, the proposed site, as illustrated in Exhibit C, is within 8 miles of the nearest port, thus limiting the natural volume of recreational boaters that would conflict with the site. The proposed site is not within a California Department of Public Health Growing Water Classification area, further testing and ongoing sampling will need to be undergone to classify the area as a "conditionally approved" shellfish growing site. The Malibu Oyster Company has engaged with officials at California Department of Public Health, Eric Trevena and Joe Christen, who indicated that the site will likely not have any major issues after hearing a description of the proposed site. While MOC will have to undergo the process outlined by the CDPH, they expect it will obtain the "conditionally approved" certificate considering the site description, as well as its proximity to Santa Barbara Mariculture (SBMC) and the existing certificate therein.

In regards to growing conditions for the proposed site, we believe depth, wave, currents, temperature and available nutrients have the potential to make this a highly productive area. Within the proposed site, depths are under 90 feet with gradually sloping declines throughout making implementation and installation of longlines advantageous. Point Dume to the northwest provides further protection from wave action within the predominantly benign conditions of the Southern California Bite. Rich nutrient upwelling from the nearby continental shelf and deep Hueneme and Mugu Canyons should provide productive growing conditions for shellfish and macroalgae alike. As the proposed site is within approximately 60 miles of Santa Barbara Mariculture, an existing operation successfully cultivating Mediterranean mussels and Pacific oysters, we believe growing conditions will not be dissimilar and should provide a proxy for conditions experienced at the proposed site. Additionally, SBMC's operation acts as a significant precedent for the project's potential lack of environmental impact. Lastly, the substrate of the region thus far appears to be completely comprised of sand and mud as illustrated in Exhibit B, which also contains an in-depth video of the landscape available through the USGS website. The USGS survey provided runs directly through the proposed site (see Exhibit B). The substrate shown here is not only beneficial for the anchoring of our site, but also proves that it will not conflict with any existing natural kelp or other cnidarian reefs.

Malibu Oyster Company's site is indicated by points MOC-NW, MOC-SW, MOC-NE and MOC-SE.

Figure 1

Latitude	Longitude	Position	Depth*
34.0258	-118.67280	MOC – NW	74 ft
34.0232	-118.67099	MOC – SW	100 ft
34.0304	-118.66207	MOC – NE	68 ft
34.0275	-118.65971	MOC – SE	86 ft

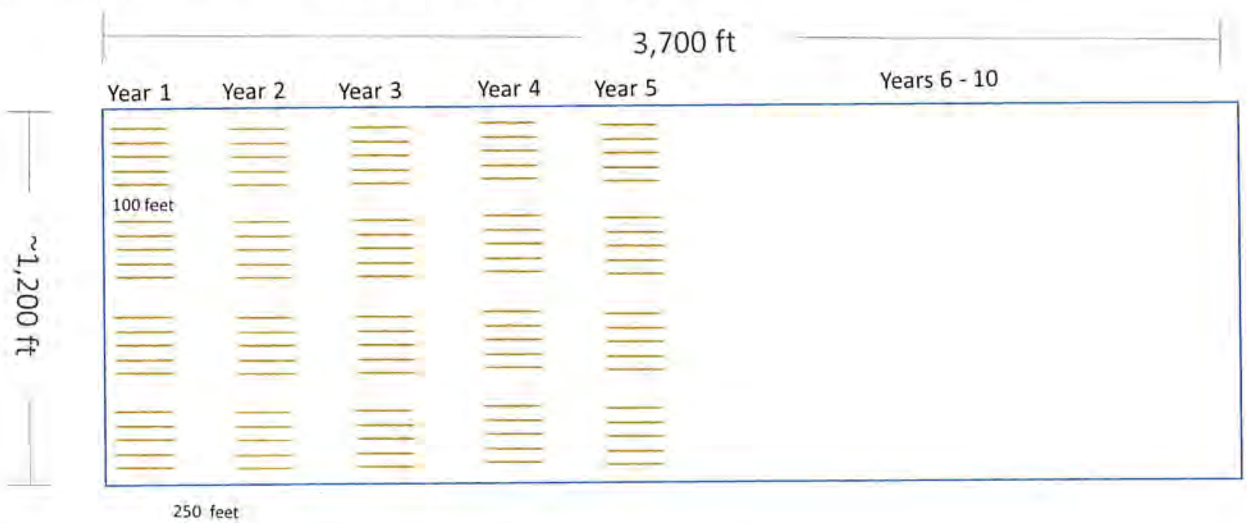
*Depths are approximated based on USGS survey data as illustrated in Exhibit B.

Plan of Development & Cultural Methods:

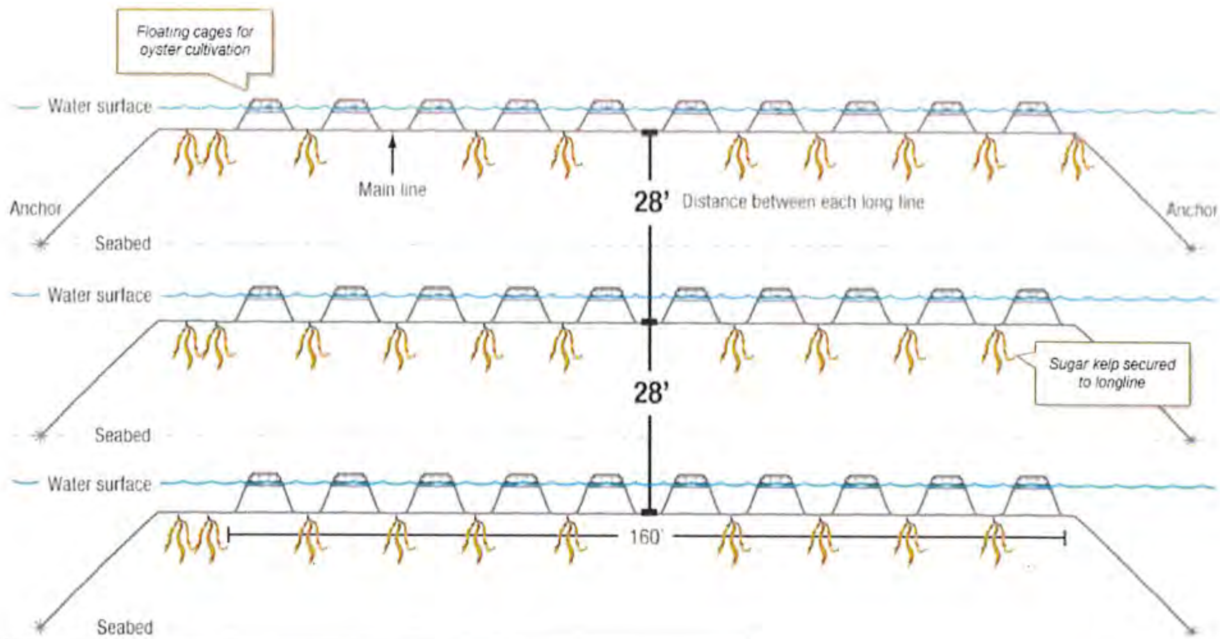
As noted above, the proposed site will occupy approximately 100 acres in eastern Malibu. The farm measures approximately 1,200 feet wide by 3,700 feet long. In accordance with U.S. Coast Guard regulations, site development will commence with the installation of marking buoys on each corner of the lease and a primary marker possessing radar reflecting capabilities within the center of the lease. This will ensure navigational visibility prior to any other activities on the site.

Deployment of longlines will begin with the installation of anchors. MOC will use 50kg Jeyco Stingray anchors, which are capable of holding 17,600 pounds each. Jeyco anchors, as displayed below in Exhibit D, are capable of holding over 10,000 pounds. With market size oysters, fully stocked floating cages will weigh approximately 100 pounds, which equates to a maximum of 1,500 pounds per longline. Jeyco stingray anchors should provide more than adequate holding power based on these projections even in extreme weather conditions. Alternatively, the farm will explore installing helical screw anchors if commercially viable. If severe hurricane conditions occur, MOC has the ability to sink the floating cages and prevent catastrophic damage to the farm and/or the spreading of marine debris.

Longlines will be approximately 150 feet long containing 10 floating cages evenly spaced 8/10 feet apart. In addition, longlines will be arranged parallel to each other and facing NW in the direction of prevailing wind patterns in order to minimize impact from wave action. Floating cages will be connected via a ½ inch polyethylene rope, which will be seasonally adorned with Sugar kelp. Spacing between each longline will be between 25 and 30 feet with 5 longlines to a group. Each group will be spaced 100 feet apart to allow ample room for mammals to echolocate these rows and navigate through if necessary. In total, this allows for 4 groupings across the width of the site. Columns will be spaced 250 feet apart. The site will be capable of holding approximately 10 columns. See below for a diagram illustrating the proposed site development, as well as longline construction.

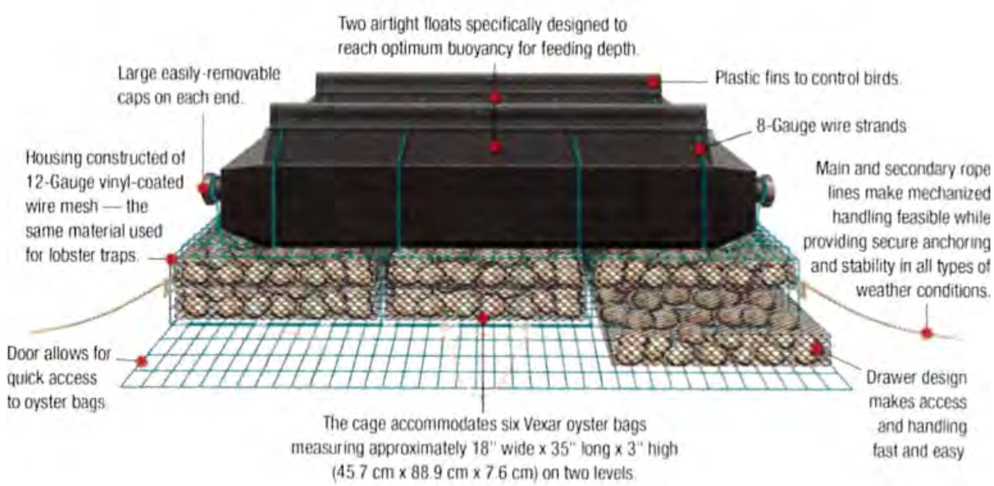


Note: Figure is not to scale. Spacing may vary depending on site specific conditions.



Note: Figure is not to scale. Spacing may vary depending on site specific conditions.

The floating cages will be assembled onshore and deployed as the farm continues to scale. Following conversations with manufacturers (Oystergro & GoDeep, Inc), MOC expects each floating cage to have an expected useful life of approximately 15 years provided they receive proper maintenance. A standard floating cage is equipped to carry six mesh plastic bags housed in a wire cage allowing for ongoing access and maintenance. Mesh bags vary in size and are rotated to maximize water flow for feeding for optimal growth rates. See below a diagram illustrating a common design for a floating cage:



- **Kelp planting & maintenance:** Kelp planting is initiated in October/November as water temperatures begin to drop. Kelp is seeded on cotton spools and wrapped around the ½ polyethylene line that connects each floating cage. Lines are moderately weighted to reach optimal depths (approximately 2 feet for growing conditions. As kelp grows throughout the season, it develops positive buoyancy due to the maturing of stipe hollows and fills with gas. When this is observed, lines will be weighted further to re-position the lines and maintain optimal depths. Kelp requires little other maintenance except from ensuring lines are not crossed or entangled, which will already be undertaken with the maintenance of the farm for oyster culture.
- **Oyster tumbling & grading:** In order to sort oysters by size, MOC will utilize an onsite portable tumbler. Oyster tumblers are generally 4-5 feet long metal tubes with two different sets of sorting sizes. Tumbling and sorting we likely be performed every 6-8 weeks due to the fast-growing conditions typically seen at the top of the water column where algae is more plentiful. Moreover, frequent tumbling of oysters chips the oyster mantle, creating a deeper cup and a higher quality oyster for the half-shell market. If oysters are deemed to be of market size, they will be taken to port at Marina del Rey where they will be graded according to quality.
- **Cage flipping and maintenance:** Floating cages offer a unique and beneficial maintenance method by which cages are periodically (generally bimonthly depending on area productivity) flipped resulting in the floats becoming fully submerged and thus exposing the mesh bags. Cage flipping can be for the immediate removal of biofouling but is also engaged for periods of up to 24-48 hours. Prolonging cage flipping removes *all* biofouling, as well as strengthens oyster abductor muscles promoting a longer post-harvest shelf life.
- **Harvesting (oysters & kelp):** Once oysters are deemed of market size and properly graded, they will be washed with a high pressure seawater hose to clean the shells of debris. The oysters will then be placed in mesh bags and moved to a temporary cold storage facility and promptly delivered fresh to local buyers in accordance with the Shellfish Handling and Marketing Certificate outlined and provided by the California Department of Public Health. Floating cages are flipped on the line for drying and removal of biofouling. They will be inspected, and if additional maintenance is deemed necessary, they will be removed from the longline and brought onshore for further upkeep. Harvesting of kelp occurs in the spring months (March/April) as the water becomes materially warmer. As a result, organisms (primarily algal in nature) begin to grow on the kelp and degrade the quality. When this growth is first observed on a blade, the kelp will be cut at the stipe, removed from the longline and immediately placed in a cooler for harvest.

Proposed Production Schedule:

Production Schedule	Year 1	Year 2	Year 3	Year 4	Year 5
New Lines Installed	20	20	20	20	20
Total Lines Operating	20	40	60	80	100
Outstanding Floating Cages	200	400	500	750	1000
Oysters Harvested (Singles)	0	250,000	500,000	750,000	1,000,000
Kelp Harvested (Tons)	10	20	30	40	50
Acres developed	5	15	25	35	50

Other Notes Regarding Best Management Practices, Community Involvement and Restoration Efforts:

Marine Debris Reduction and Management. MOC shall carry out operations consistent with the following marine debris reduction and management practices:

- **Storm Damage and Debris.** In the event that its shellfish culture gear or equipment becomes displaced or dislodged from culture lines, it shall be MOC's responsibility to retrieve the material from the shoreline, open water, or submerged bottom with minimal damage to the resources affected. Once located, such material shall be removed as soon as feasible and properly disposed of, recycled, or returned to use. As soon as safely and reasonably possible following storm or severe wind or weather events, MOC shall patrol all of its active cultivation areas for escaped or damaged aquaculture equipment. All equipment that cannot be repaired and placed back into service shall be properly recycled or properly disposed of at a certified onshore waste disposal facility. In addition, MOC shall retrieve or repair any escaped or damaged aquaculture equipment that it encounters while conducting routine daily and/or monthly maintenance activities associated with shellfish culture. If the escaped gear cannot be repaired and replaced on the shellfish bed, it shall be properly recycled or disposed of at a certified onshore waste disposal facility.
- **Gear Marking**: MOC shall mark shellfish culture bags (floating cages/bags) identifiable manner with identification information including its company name. Markings shall be securely attached and robust enough to remain attached and legible after an extended period in the marine environment (e.g. heat transfer, hot stamp, etching, etc.).
- **Marine Debris Reduction Training**: Upon receipt of their permit, MOC shall conduct an employee training regarding marine debris issues ,including covering how to identify culture gear or associated materials (longlines, label tags, clasps, etc.) that are loose or at risk of becoming loose, proper gear repair methods, and how to completely remove gear from out-of-production areas. Particular focus shall be placed on management and maintenance practices to

reduce the loss of any gear type that is frequently lost or consistently found during beach cleanup and inspection activities. These trainings shall be repeated on an annual basis throughout the term of the permit. During trainings, MOC's employees shall be encouraged to consider and implement field and management practices that reduce the amount of small plastic gear (such as zip-ties, tags and fasteners) and non-biodegradable materials used in its operations.

- **Cleanup Events:** MOC shall implement quarterly cleanup events in Malibu, Santa Monica and the South Bay in coordination with other interested parties or organizations (Heal the Bay, Oceanic Global etc.) Cleanup events shall include walking different portions of these beaches and shorelines to pick up escaped shellfish gear and other trash (regardless of whether it is generated by the project). The volume and type of shellfish gear collected and the cleanup location (marked on a map) and duration of cleanup activity shall be recorded and documented in the annual report submitted to the Executive Director of the Commission. If persistent discoveries of certain gear types are made, MOC shall evaluate (and if feasible, implement use of) alternative gear types or practices that would reduce these persistent sources of debris.
- **Excessive Gear Loss or Maintenance Failures**: If is evident that MOC is responsible for excessive loss of aquaculture equipment (long equipment, floating cages or cultivation mesh bags) into the marine environment or is consistently failing to maintain its equipment in an intact and serviceable condition, MOC shall, modify its cultivation equipment and/or operational practices to address the issue, or cease operations within a 90 day period.

Conclusion and other Notes on Methods:

As a small-scale farm, we believe floating cages are advantageous for manually flipping and servicing crop in comparison to longlines normally utilized for mussel farming—particularly as it relates to needing a vessel equipped with the ability to lift a heavy backbone line. Notably, we believe floating cages also mitigate issues related to mammalian entanglement. With only floating cages at the surface and ½ inch polyethylene line 6 -12 inches below surface, we believe this greatly lessens the risk for mammalian and/or sea turtle entanglements. Longline systems typically used for growing mussels employ a top floating line of buoys/floats (similar in scale to floating cages), a backbone line 15-20 feet below the surface with another 15-20 feet of cultured ropes hanging below the backbone. While the probability of mammalian entanglement is very low with mussel longlines, we believe the floating cage method employed here will further reduce that probability. In addition, in the case of a large storm or hurricane event, the cages can be sunk and stored on the ocean floor (this is typically done throughout the winter for farmers in northern regions where the water ices over). This not only protects the farm from catastrophic loss, but also ensures that gear and other equipment are not lost and become pollutive to neighboring areas and beaches.

EXHIBIT A

Legal description of the proposed water bottom lease for cultivation of Pacific oysters (Crassostrea gigas), Olympia oysters (Ostrea lurida), Kumamoto Oysters (Crassostrea Sikamea) and Sugar kelp (Laminaria saccharina), Crassadoma gigantea ("Giant rock scallop"), Macrocystis pyrifera ("Giant kelp"), Mesocentrotus franciscanus ("Red Sea Urchin")by The Malibu Oyster Company.

LOCATION

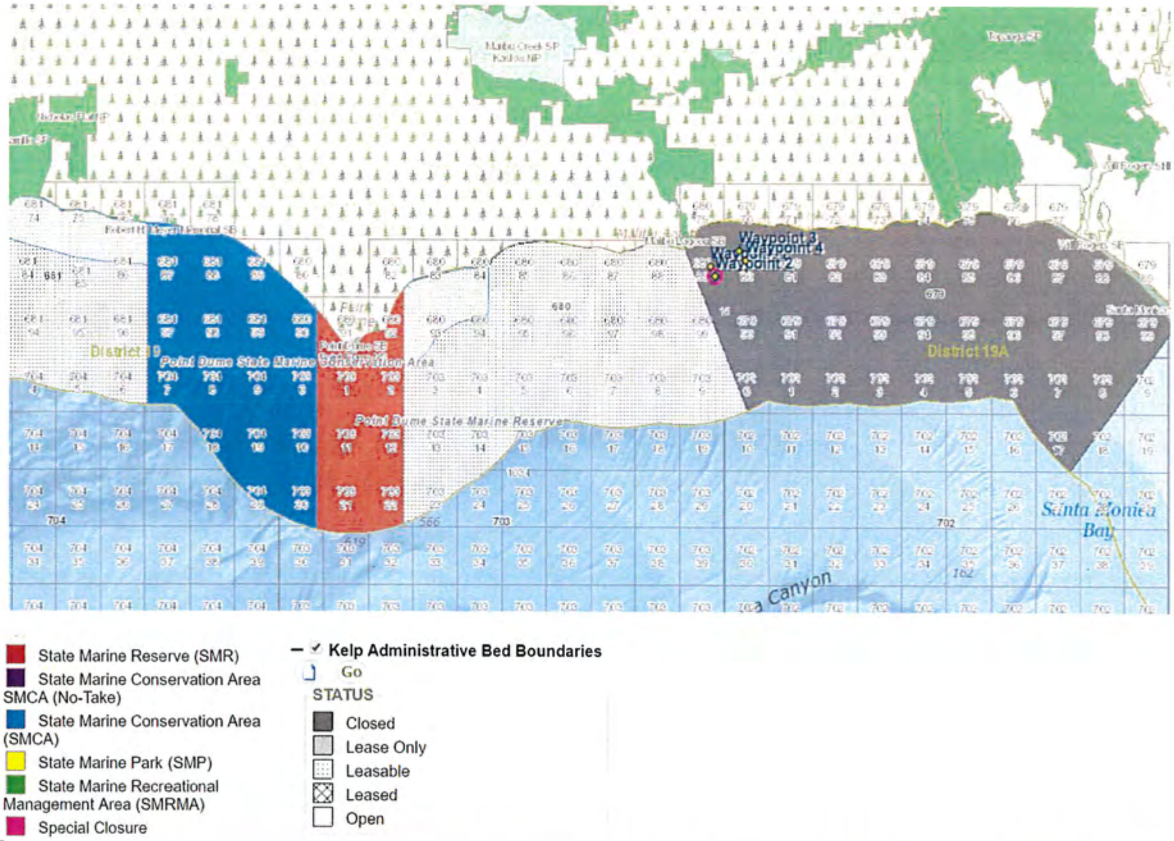
The area lying offshore of Malibu, California defined by a four-sided rectangle formed by lines connecting the following waypoints (shown in decimal degrees):

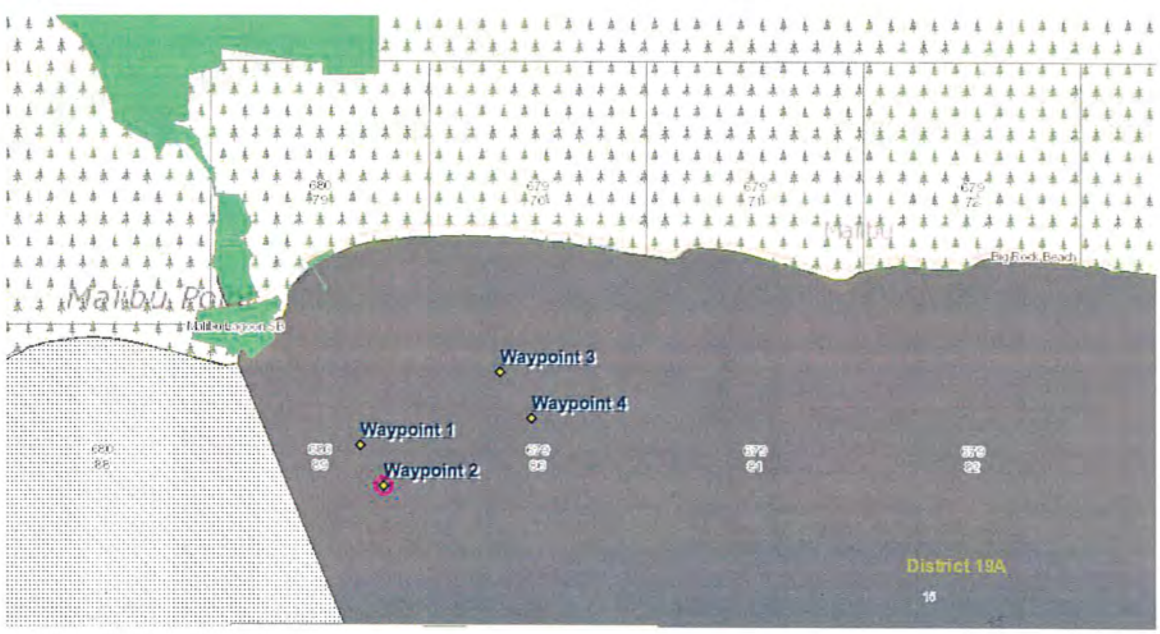
Latitude	Longitude	Position
34.0258	-118.67280	MOC – NW
34.0232	-118.67099	MOC – SW
34.0304	-118.66207	MOC – NE
34.0275	-118.65971	MOC – SE

Exhibit B

Source: USGS Coastal and Marine Geology Program. Note, the red lines denote areas where the seafloor has been mapped by the USGS. The frame in the bottom left is the view provided by the substrate rover, which provides depth levels as well.

Exhibit C

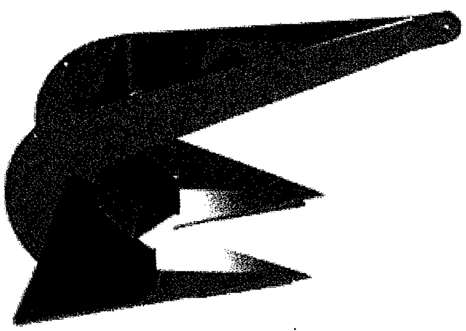


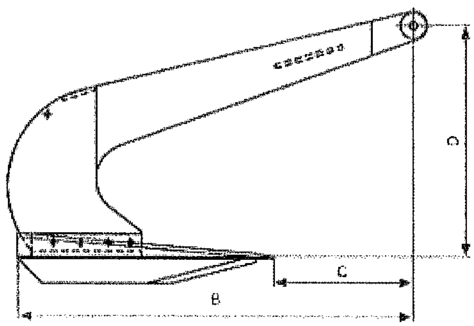


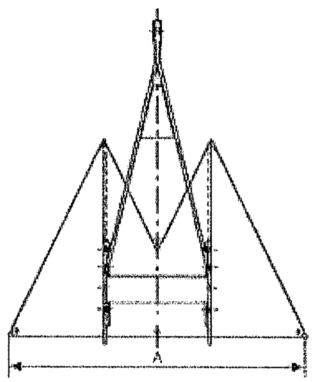
Source: California Department of Fish and Wildlife. Note, areas in Marine Reserves and leasable kelp bed boundaries are restricted for aquaculture lease.

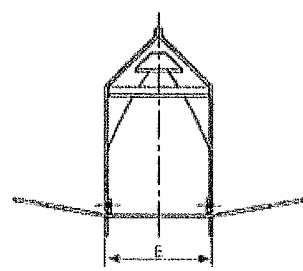
Exhibit D

Stingray High Performance Anchors









Weight (kg)	Holding Power Sand (tonnes)	Holding Power Medium Clay (tonnes)	Holding Power Silt (tonnes)
10	2.39	1.85	1.34
25	4.95	3.83	2.77
50	8.59	6.65	4.80
75	12.03	9.00	6.57
100	14.91	11.54	8.34
150	20.58	15.93	11.51
175	23.26	18.01	13.01
250	30.89	23.92	17.27
375	42.64	33.01	23.84
500	53.60	41.50	29.97
750	73.99	57.28	41.37
1000	93.00	72.00	52.00
1500	128.37	99.39	71.78
2000	161.36	124.93	90.22
3000	222.74	172.44	124.54
4000	279.98	216.76	156.55
5000	334.32	258.83	186.93

Weight (kg)	Dimensions Color	A	B	C	D	E	F
50	Green	1013	1023	347	598	368	54
75	Yellow	1060	1070	363	625	385	58
100	Blue	1171	1182	401	691	426	64
150	Green	1258	1271	432	742	458	69
250	Yellow	1515	1530	519	895	556	83
375	Blue	1748	1765	599	1031	635	96
500	Green	2024	2045	694	1190	736	111
750	Yellow	2222	2243	761	1311	808	122
1000	Yellow	2491	2516	854	1470	905	136
2000	Yellow	3078	3109	1055	1817	1119	168
3000	Yellow	3638	3719	1312	2160	1311	197
5000	Yellow	4248	4291	1456	2504	1544	232

State of California
Department of Fish and Wildlife

Received September 17, 2019
Original signed copy on file.

M e m o r a n d u m

Date: Sept 16, 2019

To: Melissa Miller-Henson
Executive Director
Fish and Wildlife Commission

From: Charlton H. Bonham
Director

Subject: **Request to consider the new state water bottom lease application received from J.P Garofalo and Nick Mercer, doing business as Malibu Oyster Company, for an approximately 100-acre parcel in offshore waters near Malibu, CA.**

The Department of Fish and Wildlife (Department) requests that pursuant to Fish and Game Code § 15404, the Fish and Game Commission (Commission) finds that the area of the proposed new state water bottom lease for shellfish aquaculture, received from J.P. Garofalo and Nick Mercer, doing business as Malibu Oyster Company (MOC), is available, finds that the lease would be in the public interest, and direct staff to proceed with next steps in preparation for consideration of the lease (including the posting of public notices, tribal outreach, environmental review, and interagency coordination).

Background

The Commission received an application for a new state water bottom lease for shellfish and seaweed aquaculture at its June 12-13, 2019 meeting under Public Comment. The applicant proposes to establish a commercial offshore bivalve shellfish and seaweed aquaculture operation with Pacific oysters (*Crassostrea gigas*) and Sugar kelp (*Laminaria saccharina*) being the primary products. The proposed lease area is approximately 100 acres located about one-half mile offshore from Malibu Pier (Malibu, CA). The cultivation gear proposed would consist of a submerged longline system, with attached floating cages for the shellfish and directly seeded longlines for the seaweed. Harvested product would be landed at Marina del Rey Harbor.

Public Resources Code declares it in the public interest to expand aquaculture activity[1], as does Fish and Game Code in statutory policy that, among other things, encourages the development of commercial aquaculture[2]. These policies apply in a broader sense, but the public interest consideration may be further informed by site-specific considerations that may be immediately apparent, such as previous encumbrances of the location by other leases issued or recorded by the State Lands Commission, or prohibitions on sanitary or public health grounds

[1] The Aquaculture Development Act (Pub. Resources Code, § 826.).
[2] Fish & G. Code, § 1700.

as managed by the Department of Public Health. The public hearing and CEQA processes of the Commission are meant to provide for more in-depth environmental considerations and stakeholder input before approving new leases, so support for recommending this ‘public interest’ determination should take the form of preliminary site-specific considerations.

Pursuant to California Code of Regulations, Title 14, Section 237(b)(3), Department staff requested certification from the California State Lands Commission (SLC) that the state water bottom area proposed by Malibu Oyster Company is unencumbered. In a letter dated July 16, 2019 (Ref # 1217) certification was received from SLC affirming the absence of conflicting leases within the proposed aquaculture area.

In addition, preliminary evaluation of recreational and commercial fishing data did not immediately indicate the proposed project conflicts with these uses.

The applicants have also been coordinating with the CA Department of Public Health (CDPH) to determine whether their proposed site will likely achieve certification as a growing area from a public health perspective. A proposed site Sanitary Survey and certification will be conducted once the applicant has standing with a Commission-approved state water bottom lease. CDPH preliminary review has provided no indication to preclude further consideration of the proposed site in advance of a complete Sanitary Survey.

Coastal Commission staff has pointed out the potential for perceived conflict with a nearby designated surfing reserve (Malibu World Surfing Reserve). The attached map reflects the approximate relative locations of the reserve and proposed lease site, separated by approximately 1600 feet beyond the outermost boundary of the reserve (which itself extends about 1640 feet from shore).

In addition, the proposed project is larger-scale and has numerous novel components, which should be carefully evaluated through the CEQA process. The proposed lease size of 100 acres is larger than any offshore aquaculture facility currently operating in California state waters. Potentially significant site-specific impacts to habitat and species of concern (e.g., marine mammal entanglement) of this proposal should be evaluated. In addition, four of the seven species proposed for culture have not yet been commercially cultivated in California state waters. The resource implications of commercially cultivating novel species, including Sugar kelp (*Laminaria saccharina*), Giant rock scallop (*Crassadoma gigantea*), Giant kelp (*Macrocystis pyrifera*), and Red sea urchin (*Mesocentrotus franciscanus*) should be carefully evaluated. Similarly, the applicants propose to cultivate shellfish and kelp species using methods that have not yet been employed in the offshore environment of California state waters. The potential impact of these types of novel methods to marine resources should be assessed.

Future Commission hearings and the CEQA environmental review and disclosure processes will provide additional opportunity for applicant and stakeholder input regarding this proposed new operation and potential further siting refinements.

Based on these initial evaluations, the Department recommends the Malibu Oyster Company application is in the public interest, and seeks Commission direction to proceed with next steps in preparation for consideration of the lease, including the posting of public notices, tribal outreach, environmental review, and interagency coordination.

Please direct further questions to Randy Lovell, State Aquaculture Coordinator at (916) 445-2008 or aquaculturecoord@wildlife.ca.gov.

Attachment

ec: Stafford Lehr, Deputy Director
Wildlife and Fisheries Division
Stafford.Lehr@Wildlife.ca.gov

Craig Shuman, D. Env. Regional Manager
Marine Region
Craig.Shuman@Wildlife.ca.gov

Randy Lovell, State Aquaculture Coordinator
Wildlife and Fisheries Division
Randy.Lovell@Wildlife.ca.gov

Kirsten Ramey, Program Manager
Marine Region
Kirsten.Ramey@Wildlife.ca.gov

Subject: FW: Malibu Oyster Co. FGC App - Additional Letter of Support
Attachments: Malibu Oyster Company Letter of Support.pdf

From: Lovell, Randy@Wildlife <Randy.Lovell@wildlife.ca.gov>
Sent: Tuesday, September 10, 2019 5:22 PM
To: FGC <FGC@fgc.ca.gov>; Pope, Elizabeth@FGC <elizabeth.pope@fgc.ca.gov>
Cc: Nick Mercer [redacted]; Laoyan, Renee@Wildlife <Renee.Laoyan@wildlife.ca.gov>; J.P. Garofalo [redacted]
Subject: RE: Malibu Oyster Co. FGC App - Additional Letter of Support

Hi Elizabeth -

Please include this additional comment letter in the Oct binder under Malibu Oyster Co's lease application item.

Thank you,

Randy.

RANDY LOVELL
STATE AQUACULTURE COORDINATOR
CA DEPT FISH & WILDLIFE
SACRAMENTO CA
916-445-2008
RANDY.LOVELL@WILDLIFE.CA.GOV
WWW.AQUACULTUREMATTERS.CA.GOV

From: J.P. Garofalo [redacted]
Sent: Monday, September 09, 2019 10:55 PM
To: Lovell, Randy@Wildlife <Randy.Lovell@wildlife.ca.gov>
Cc: Nick Mercer [redacted]; Laoyan, Renee@Wildlife <Renee.Laoyan@wildlife.ca.gov>
Subject: Malibu Oyster Co. FGC App - Additional Letter of Support

Hi Randy,

I hope all is well and you had a great summer. Hard to believe it's already September!

With the October Commission meeting 1 month away, we wanted to provide an official additional letter of support we received from Michael King at King's Seafood. Could you please include this in the application as well? Is there anything else we need to do to get on the agenda at this juncture? Pleas let us know when you get a moment. Thanks and looking forward to connecting with you soon.

Sincerely,

JP & Nick
Malibu Oyster Co.

To: California Fish and Game Commission
Date: August 2, 2019

I am writing this letter in support of Malibu Oyster Company and their application for a California State Water bottom lease located off the coast of Malibu, California. With support from the Fish and Game Commission, alongside the Department of Fish and Wildlife, Malibu Oyster Company will be able to provide local product to one of the world's largest markets and be a leader in the burgeoning aquaculture industry here in California.

King's Seafood Company is now in its 75th year of business in Southern California, and the continual development of the seafood culture in this region is very important to us. As a local restaurant company with 22 restaurants, we are excited to offer great local products that we can share with our Guests. As a seafood distributor, we look forward to seeing another great California product on the market. And, perhaps most importantly, as a participant in the ongoing dialogue of seafood sustainability we are excited about Malibu Oyster Company showcasing that Southern California can be a leader in the aquaculture industry.

As a pioneering aquaculture farm in Southern California, we believe Malibu Oyster Company presents a unique opportunity to advance a sustainable form of local production in Southern California.

Thank you for your time and the consideration.

Sincerely,

Michael King
King's Seafood Company

Subject: FW: AGENDA #19: MALIBU OYSTER COMPANY APPLICATION FOR STATE WATER BOTTOM LEASE
Attachments: Malibu Historic District - map.pdf; SeaOfClouds - FGC Agenda 19 - 20190926.pdf

From: Michael Blum <theseaofcloudsproject@gmail.com>
Sent: Thursday, September 26, 2019 04:34 PM
To: FGC <FGC@fgc.ca.gov>
Subject: AGENDA #19: MALIBU OYSTER COMPANY APPLICATION FOR STATE WATER BOTTOM LEASE

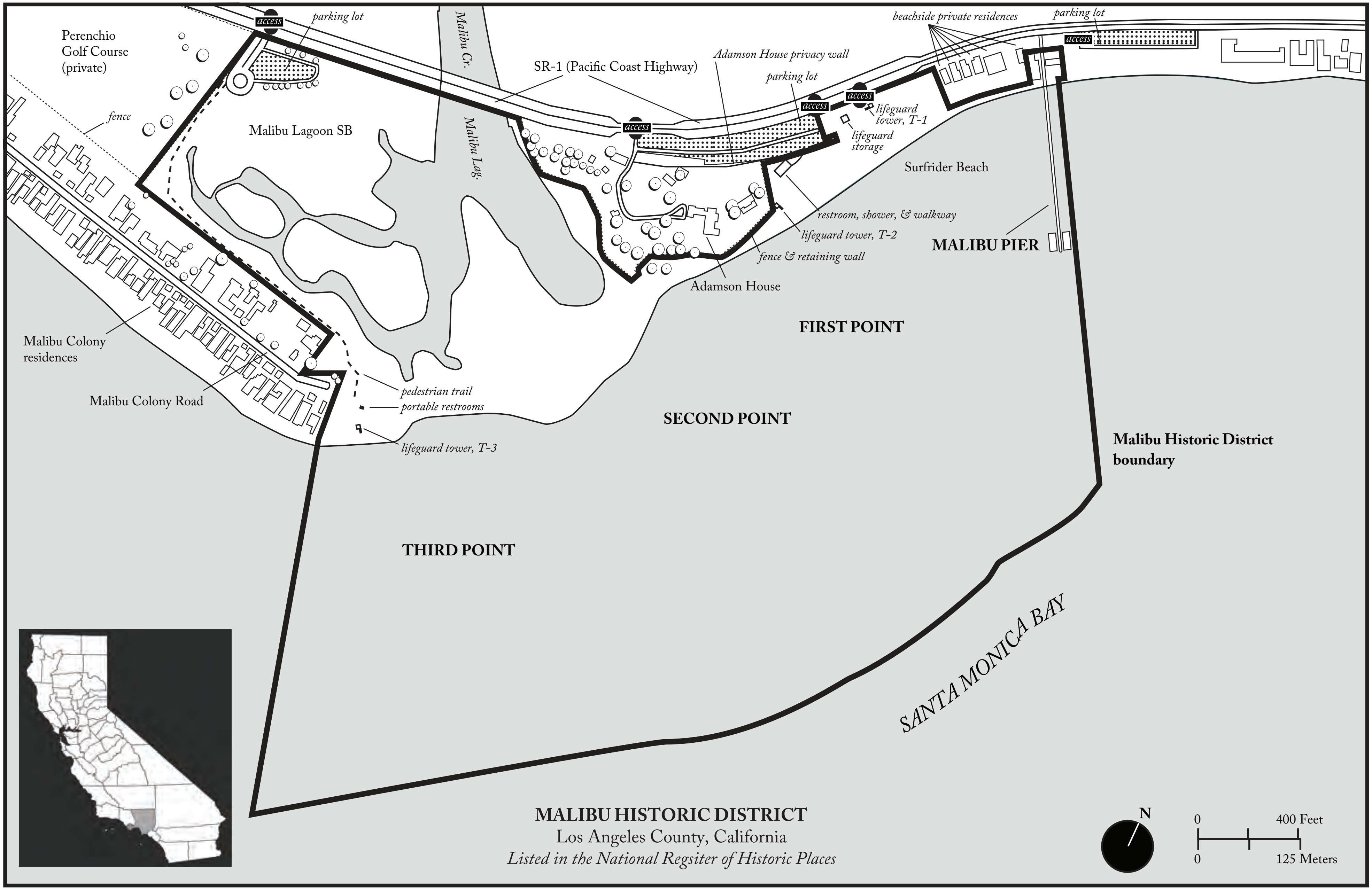
Dear President Sklar,

Good day. Attached please find our comment letter on Agenda #19 of the upcoming Calif. Fish and Game Commission meeting: Malibu Oyster Company Application for State Water Bottom Lease.

Also, please find attached a map of the nearby Malibu Historic District, a listing in the National Register of Historic Places, which recognizes the area's worldwide contributions to the sport of surfing.

Thank you for your consideration of our comments. I'm available at your convenience to respond to any questions.

Regards,
Michael Blum
Executive Director
Sea of Clouds



MALIBU HISTORIC DISTRICT

Los Angeles County, California

Listed in the National Regsiter of Historic Places

Prepared by Sea of Clouds\ seaofclouds.org

February, 2018

SEA of CLOUDS

September 26, 2019

California Fish and Game Commission
ATTN: Erik Sklar, President
P.O. Box 944209
Sacramento, California 94244-2090
SENT VIA EMAIL

RE: AGENDA #19: MALIBU OYSTER COMPANY APPLICATION FOR STATE WATER BOTTOM LEASE

Dear President Sklar,

We are a multi-disciplinary nonprofit practice engaged in recognizing and protecting America's special coastal places. A recent project (2018) listed the iconic Malibu surfing area (designated as the Malibu Historic District; generally Malibu Pier, Malibu Surfrider Beach, Malibu Lagoon, and the area's three famous surf breaks) in the National Register of Historic Places, recognizing its significant worldwide contributions to the sport.[1] This is the first National Register listing centered on surfing history; fitting of Malibu's significant recreational value.

As Mr. Skylar Peak, a current City of Malibu Councilmember and former Mayor, said of Malibu's importance:

> "[Malibu] has long been a destination for beach goers and surfers alike while acting as the catalyst destination for the Southern California surfing community in shaping its surf and beach culture seen on the worldwide stage. This beautiful beach and cobble point-break with the back drop of the Malibu Pier creates a perfect wave when the south swell is up and hosts millions of visitors on an annual basis. The district honors a generation who created surfing history here and whose legacy you see today surfing at First Point. I'm excited to celebrate the listing with our residents, other Angelenos, and the world community of surfing, Aloha!" [2]

It is within this context that we express concern whether the application before your commission for a 100-acre aquaculture facility sited 1 mile offshore is in the public interest. Malibu's surfable waves constitutively depend upon uninterrupted wave energy passing through the

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proposed facility site as it approaches the shore. These "swell corridors" -- offshore regions where ocean swells travel (sometimes over great distance) and eventually transform into surfable waves -- are recognized elsewhere in coastal zone management policy. [3] We urge you to consider Malibu's characteristic swell corridor in your application review. We contend that the proposed facility, sited within the Malibu swell corridor and so close to the area which has otherwise been protected, is an incompatible use. We also register some concern that materials dislodged from the facility may represent a hazard to surfers at Malibu, one of Los Angeles' most crowded beaches.

In our comments below, we provide an overview of wave forecasting, Malibu's surfing geography, and how swell corridors are considered in New Zealand coastal policy. Finally, we provide an appendix listing Malibu's surfing honors and designations demonstrating its significant recreational value.

WAVE FORECASTING

With its pronounced south-facing exposure, Malibu usually receives surfable waves during the spring through fall months either from storms formed in the southern Pacific basin or from equatorial hurricane (cyclonic) activity. Waves at Malibu are almost always smaller than north-facing California beaches that receive greater intensity, wintertime, storm swells. Additionally, Malibu generally receives less swell energy than other, more exposed, areas in Southern California due to "shadowing" from offshore islands, i.e., large, geologic features that dissipate wave energy before reaching the coast. At Malibu, the primary swell corridors through which wave energy passes uninterrupted are from a) the south to southwest (170-205 degrees) and b) from the southwest to west-southwest (225-260 degrees). Between 200-225 degrees, shadowing occurs from the offshore San Nicholas and Santa Barbara Islands, from the south-southwest (190-200 degrees) from the Cortes Bank, and from less than 175 degrees the Santa Catalina and San Clemente Islands.[4]

WAVE FORMATION

Surfing is site-specific; coastal and nearshore physical features determine specific wave typologies. Coral reefs, submarine canyons, and nearshore sandbars are features associated with specific types of surf breaks and a range of surfable wave heights. Point break surfing areas are a wave type influenced by river or creek outflows. Incoming wave energy focuses around a point of land and refracts (bathymetric defocusing) as it breaks toward a cove. Although defocused wave energy at a point break reduces overall wave size, it produces long and well-formed waves. Malibu, like several of California's premier surfing areas, is a point break. While the contribution of nearby Malibu Creek's material outflow to Malibu's wave quality is not exactly known, the consensus is that the nearshore cobblestone reef and seasonal sand nourishment of Malibu through Malibu Lagoon are important components. To a lesser extent, material transport into Malibu also occurs parallel to shore, part of a closed, larger-scale conveyance known as a littoral cell. Malibu is part of the Santa Monica Littoral Cell, extending from Point Dume in the City of Malibu southward to the Palos Verdes peninsula. Estimated annual sediment drift rates for the Santa Monica Littoral Cell vary between 5.3 and 10.6 million cubic feet.[5]

SURFING AT MALIBU

Surfing is an interaction between incoming wave energy and a specific, complex, biophysical environment. Like many forms of outdoor recreation, surfing is site-specific -- possessing an identifiable combination of quality and character. Different surfing styles or performance standards are associated with specific surf breaks. Surfing is also site-dependent, requiring an explicit, and often contested, set of coastal resources. Site-specific and site-dependent surfing resources incorporate a) beaches and nearshore areas where waves collapse—or “break”—in shallow water and in consistent patterns as to support surfing, b) larger surfing areas—as a complex of proximate surf breaks, and c) other physical and associative features that collectively make a site unique. The long, well-formed, and consistent waves of Malibu are characteristic of surfing point breaks and make it, along with its associative features, one of the world’s most recognizable surfing areas. To recognize its importance as a high-quality surfing area, Malibu is the only beach in Los Angeles County designated as “no swimming,” i.e., surfing only.[6] There are three surf breaks that form the Malibu surfing area.

SWELL CORRIDORS

Swell corridors are offshore areas through which wave energy travels and transforms into surfable waves.[7] They are constitutive parts of a surfing resource, describing not where surfing waves originate but where wave energy travels through ultimately to a surfing site. The 2010 New Zealand Coastal Policy Statement (NZCPS) -- the national policy which guides local authorities in day-to-day management of the coastal environment recognizes both: a) surf breaks of national significance, and b) swell corridors requiring protection. New Zealand resource managers have considered a portfolio of offshore projects, including: energy infrastructure, dredge spoil disposal, and aquaculture for their effects on swell corridors. Stevens et al. (2008) demonstrate effects of long line shellfish aquaculture on swell corridor wave energy; effects depend upon wave period, proximity to the shoreline, and facility scale.[8]

We repeat our contention that the proposed facility, sited within the Malibu swell corridor and so close to an area which has otherwise been protected, is an incompatible use. Coastal recreation resources, including surfing resources, are public goods to be recognized, celebrated, properly managed, and protected. Protecting Malibu, an exceptional surfing resource of international renown, is in the public interest and should be included in your review of the application. More generally, it is likely more important for resource managers to consider avoiding harmful or negative effects on surf breaks as it is to consider mitigation or post-facto remediation, since the latter efforts have proven to be difficult, impractical, and/or largely unsuccessful.

We recognize and appreciate that this is a preliminary review of the proposed facility. Still, we do not believe the facility should be considered for this location. We recommend that you require applicants to find an alternative facility site. We applaud the applicants for their commitment to sustainably grown, locally-harvested shellfish and we support their interest in developing such facilities within Santa Monica Bay. We welcome the opportunity to work with applicants and other interested parties to find a suitable, alternative site location.

Thank you for your consideration and your work to preserve California's wildlife heritage. I'm available at your convenience to respond to any questions.

Kind regards,

Michael Blum
Executive Director

Attachment

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1. NRHP Ref No. 100002022.

2. Sea of Clouds, 2018. Iconic Malibu Surfing Area Added to National Register of Historic Places <seaofclouds.org/resources/news/20180202-malibu-historic-district.html> (accessed 9/25/2019)

3. New Zealand Coastal Policy Statement (2010) - a national policy guiding local authorities in the management of the coastal environment. <doc.govt.nz/about-us/science-publications/conservation-publications/marine-and-coastal/new-zealand-coastal-policy-statement/new-zealand-coastal-policy-statement-2010/>

4. Sean Collins, "The Mechanics of Malibu," Surfline.com, accessed November 1, 2015. http://www.surfline.com/surf-news/malibu-surf-mechanics_55498.

5. Kiki Patsch and Gary Giggs, Development of Sand Budgets for California's Major Littoral Cells (University of California Santa Cruz, January 2007).

6. Los Angeles, California, County Code § 17.12.510.

7. See the Aukland, NZ swell corridor visualization tool at <dumpark.com/swellCorridor/>

8. Stevens, C., D. Plew, N. Hartstein and D. Fredriksson, 2008. The Physics of Open-Water Shellfish Aquaculture. Aquacultural Engineering, 38(3): 145-160.

APPENDIX A.1 - MALIBU'S SURFING DESIGNATIONS / RECOGNITIONS

. World Surfing Reserve (2010) <savethewaves.org/programs/world-surfing-reserves/reserves/malibu/> (accessed 9/25/2019)

. National Register of Historic Places (2018) <nps.gov/places/malibu-historic-district.htm> (accessed 9/25/2019)

. Referenced in state bill (AB 1782) establishing surfing as California's official state sport <leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB1782> (accessed 9/25/2019)

. Rated up to "9" on 10-point scale of wave quality by Surfline / Wavetrak "Perfect-O-Meter" <surfline.com/surfdata/report_breakdata.cfm?id=4209&sef=true> (accessed 9/25/2019)

. Site of professional surfing competitions, including: (Surf Relik (2019, 2018); Rip Curl Pro (2006); Body Glove Hawaiian Airlines Pro (1995); Oxbow World Longboard Championships (1994); Acura Integra Malibu Pro (1993); Sunkist U.S. Pro (1979); U.S. Pro Invitational (1981); Hang Ten Women's International Pro Surfing Championships (1975))

. Site of annual club-level surfing competitions, such as the Malibu Surfing Association's MSA Classic Invitational

APPENDIX A.2 - MALIBU FIRSTS

. In surfing, longboards are referred to as "Mals" — short for "Malibu board" — by Australian and UK surfers.[1] Similarly, longboard-based surfing clubs in Australia and the UK are named "Malibu Clubs", *e.g.*, Noosa Malibu Club (Queensland, AU)

. Malibu Surfrider Beach is the only beach in Los Angeles County to be designated "no swimming," *i.e.*, surfing only.[2]

. Malibu has been featured in over 100 surfing films, including: *The Endless Summer* (1966), *Cosmic Children* (1970), *Legends of Malibu* (1987), *The Seedling* (1999), *One California Day* (2007), and Mind Over Malibu (2012)[3]

. In 1984, a group of area surfers founded the Surfrider Foundation in response to Malibu Point's longstanding water quality impairments. Today, Surfrider Foundation is the surfing community's largest environmental nonprofit, maintaining over 250,000 members across 84 chapters in the United States and with affiliates in over 20 countries worldwide.[4]

APPENDIX A.3 - MALIBU ON 'BEST OF' SURFING LISTS (accessed 9/16/2019)

. 8 Best Surf Spots in Southern California, Wavehuggers.com
<wavehuggers.com/general/10-best-surf-spots-southern-california>

. 11 Awesome Surf Spots, Visit California
<visitcalifornia.com/attraction/11-awesome-surfing-spots>

. California's Most Stunning Surf Spots, Los Angeles Magazine
<lamag.com/culturefiles/surfing-california-official-sport/>

. California's Seven Best Surf Spots, Mr. Porter
<mrporter.com/en-us/journal/on-the-road/californias-seven-best-surf-spots/2075>

. California Surf and Travel Guide, Surfline
<surfline.com/travel/united-states/california-surfing-and-beaches/5332921>

. Longboard Surfing in California, USA Today
<traveltips.usatoday.com/longboard-surfing-california-101697.html>

. Ride the Waves at the Top 10 Surf Spots in California, US Coachways
<uscoachways.com/blog/ride-the-waves-at-the-top-10-surf-spots-in-california/>

. Surfing in California: Your Guide to the Best Waves, Tripaneer
<booksurfcamps.com/news/surf-spots-california>

. Surf's Up: Great Surf Spots in Southern California, KCET
<kcet.org/shows/socal-wanderer/surfs-up-great-surf-spots-in-southern-california>

. The Best Southern California Surf Spots, Surfer Today
<surfertoday.com/surfing/the-best-southern-california-surf-spots>

. The Best Surf Spots in Southern California, Columbia
<blog.columbia.com/best-surf-spots-southern-california/>

. The Best Surfing Beaches in California, California Beaches
<californiabeaches.com/the-best-surfing-beaches-in-california/>

. Where to Surf in Los Angeles, Discover Los Angeles
<discoverlosangeles.com/things-to-do/where-to-surf-in-los-angeles>

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1. “Objects Through Time: 1949 Malibu Surfboard.” *Migration Heritage Center of New South Wales*. Accessed November 1, 2015. <migrationheritage.nsw.gov.au/exhibition/objectsthroughtime/surfboard>

2. Los Angeles, California, County Code § 17.12.510.

3. Warshaw, Matt. *The Encyclopedia of Surfing*, edited by Matt Warshaw, Orlando, FL: Harcourt, Inc., 2003.

4. surfrider.org.

To: Ashcraft, Susan@FGC; Pope, Elizabeth@FGC; Miller-Henson, Melissa@FGC
Subject: RE: Razor Clam Domoic Acid Results, Humboldt County

From: Christen, Joe@CDPH <Joe.Christen@cdph.ca.gov>
Sent: Wednesday, September 4, 2019 10:08 AM
To: Ashcraft, Susan@FGC <Susan.Ashcraft@fgc.ca.gov>; Christine Cosby <ccosby@yuroktribe.nsn.us>; Walker, David@Wildlife <David.Walker@wildlife.ca.gov>; Grant, Christina@CDPH <Christina.Grant@cdph.ca.gov>; Coe, Hannah-Contractor@Wildlife <Hannah.Coe@Wildlife.ca.gov>; Jacque Smith [redacted]; Jaytuk Steinruck <jaytuk.steinruck@tolowa.com>; Grebel, Joanna@Wildlife <Joanna.Grebel@wildlife.ca.gov>; Ken Graves [redacted]; Ramey, Kirsten@Wildlife <Kirsten.Ramey@wildlife.ca.gov>; Martel, Melissa (HUMBOLDT COUNTY) <mmartel@co.humboldt.ca.us>; Rosa Laucci <Rosa.Laucci@tolowa.com>; Klasing, Susan@OEHHA <Susan.Klasing@oehha.ca.gov>; Suzanne Fluharty <sfluharty@yuroktribe.nsn.us>; Tom Weseloh (Tom.weseloh@sen.ca.gov) <Tom.weseloh@sen.ca.gov>; Trevena, Eric@CDPH <Eric.Trevena@cdph.ca.gov>; Ray, James@Wildlife <James.Ray@wildlife.ca.gov>
Cc: Zubkousky, Vanessa@CDPH <Vanessa.Zubkousky@cdph.ca.gov>
Subject: Razor Clam Domoic Acid Results, Humboldt County

Good morning –

Results for domoic acid in razor clam meat for clams collected by James Ray from Clam Beach in Humboldt County are tabulated below.
DA ranged from < 2.5 to 37 ppm with an average of 17 ppm; 3 out of 10 samples tested over 20 ppm.

Sample	Domoic acid (ppm)	Collection Date	Agency	Site
Razor Clam - Meat	< 2.5	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	4.6	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	6.5	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	8.8	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	9.2	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	18	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	18	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	**22**	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	**27**	08/03/19	CDFW	Clam Beach
Razor Clam - Meat	**37**	08/03/19	CDFW	Clam Beach

Joe Christen
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Environmental Health Services Section
850 Marina Bay Parkway, G-165
Richmond, CA 94804
510 412-4638
Joe.Christen@cdph.ca.gov

Tracking Number: (2019-014)

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, 1416 Ninth Street, Suite 1320, Sacramento, CA 95814 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
   Name of primary contact person: Karen Martin, PhD
   Address: [redacted]
   Telephone number: [redacted]
   Email address: karen.martin@pepperdine.edu

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: **Fish and Game Code Section 8381;** Section 28.00 cites sections 200, 202 205, 210, 219, and 220 of the Fish and Game Code. Section 200 is relevant as this is not a commercial take. Section 202 was repealed Stats 2016. Section 205 is relevant as it allows the Commission to change or abolish an open season and to establish or change a bag limit. Section 210 is repealed Stats 2016. Section 219 is relevant as it provides the Commission authority to act to protect fish, wildlife, and natural resources. Section 220 is repealed Stats 2016**.**

3. **Overview (Required) -** Summarize the proposed changes to regulations: 1) Change the bag limit from "none" to "ten of one species" for California Grunion *Leuresthes tenuis*; 2) Reduce the length of the seasonal closure for California Grunion; 3) Shift the timing of the seasonal closure north of Pt. Conception for California Grunion.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: **See Attached for full text:** Rationale for request for change in regulations: Unique Species Targeted During Critical Reproductive Season in a Shrinking Habitat

SECTION II: Optional Information

5. **Date of Petition: June 2019**

6. Category of Proposed Change

☒ Sport Fishing
☐ Commercial Fishing
☐ Hunting
☐ Other, please specify:

7. The proposal is to: (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)

☐ Amend Title 14 Section(s):27.60(b); no bag limit, to 27.60 (a), limit of 10 for one species; Section 28.00, seasonal closure, may be taken June 1 – March 31; change to July 1 – March 31 south of Pt. Conception. North of Pt. Conception, seasonal closure, change so may be taken September 1 – March 31. Section 28.00 cites sections 200, 202 205, 210, 219, and 220 of the Fish and Game Code. Section 200 is relevant as this is not a commercial take. Section 202 was repealed Stats 2016. Section 205 is relevant as it allows the Commission to change or abolish an open season and to establish or change a bag limit. Section 210 is repealed Stats 2016. Section 219 is relevant as it provides the Commission authority to act to protect fish, wildlife, and natural resources. Section 220 is repealed Stats 2016.
☐ Add New Title 14 Section(s):
☐ Repeal Title 14 Section(s):

8. If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition

Or ☒ Not applicable.

9. Effective date: If applicable, identify the desired effective date of the regulation. If the proposed change requires immediate implementation, explain the nature of the emergency: April 2020

10. Supporting documentation: Identify and attach to the petition any information supporting the proposal including data, reports and other documents: Powerpoint about California grunion, scientific journal article on population trends of California grunion .

11. Economic or Fiscal Impacts: Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing: There is no commercial fishery and it is illegal to sell recreational catch. No gear is legal for this species. It is unlikely that there will be negative economic impacts from reduced recreational fishing. It is possible that improved grunion runs will attract tourism for wildlife watching during the expanded closed season. Tourism agencies in coastal cities currently list grunion runs as an attraction.

12. Forms: If applicable, list any forms to be created, amended or repealed:

SECTION 3: FGC Staff Only

Date received: Received by email on Thursday, June 20, 2019 at 7:22 AM.

FGC staff action:

- ☑ Accept - complete
- ☐ Reject - incomplete
- ☐ Reject - outside scope of FGC authority

Tracking Number 2019-014

Date petitioner was notified of receipt of petition and pending action: August 7-8, 2019

Meeting date for FGC consideration: October 9-10, 2019

FGC action:

- ☐ Denied by FGC
- ☐ Denied - same as petition ____________________
  Tracking Number
- ☐ Granted for consideration of regulation change

Received by email on Thursday, June 20, 2019 at 7:22 AM as attachment 1 to petition 2019-014

Rationale for request for change in regulations: Unique Species Targeted During Critical Reproductive Season in a Shrinking Habitat

Life History and Current Regulations:

California grunion *Leuresthes tenuis* (Atherinopsidae), indigenous endemic marine fish, emerge out of water onto sandy beaches on the Pacific coast of California and Baja California to reproduce (Gregory, 2001). In a unique recreational fishery, people capture these fish out of water with bare hands during their midnight spawning runs (Spratt, 1986; Sandrozinski, 2013).

Because of their unusual life cycle, California Grunion are particularly vulnerable to overharvest. Less than 10 years after the first published scientific description of their spawning behavior (Barnhart, 1918; Thompson,1919), the first regulations to protect them were enacted in 1927 (Clark, 1926, 1938) by the California Department of Fish and Game (now Wildlife), CDFW. At that time, people would line the shore, capturing hundreds of grunion with improvised nets made of bed sheets (Andrew Olson, Jr., personal communication), using them for food and fertilizer.

Early protections included a seasonal closure, with no take from April through June, the peak of the spawning season. Gear restrictions specify no gear at all; only bare hands are allowed for capturing these fish, presumably to give them a sporting chance while on shore. Under the age of 16, children do not need a fishing license to catch grunion during open season. No commercial use of the species is permitted. However, there is no bag limit, and no requirement to report recreational catch of this species.

Walker (1949) observed grunion runs on Scripps Beach directly following World War II. Based on his recommendations, CDFW shortened the seasonal closure to April and May. Gear restrictions and license requirements remained in place. At that time California's population was substantially smaller, 10 million. Today, more than 35 million people live along one of the most densely populated coasts in the world, and millions more visit as tourists.

Sandy beaches are critical to California grunion as Essential Fish Habitat for spawning (Robbins 2006). However, beaches in California and worldwide are losing habitat by coastal squeeze (Defeo et al., 2009; Shoeman et al., 2014; Martin, 2015), with sea level rise and erosion encroaching on the beach from the seaward side, and coastal development and seawalls preventing natural retreat of the beach on the landward side (Dugan et al., 2008). Exacerbated by climate change and increasing human population, California is predicted to lose 31 to 67% of its sandy beaches by the year 2100 under current predictions of sea level rise (Vitousek et al., 2017).

Current uses of California Grunion:

Some anglers catch this species for bait, some people catch these small fish to consume whole, but most of those capturing the grunion report they are doing so for the sport, not for any specific use but because hunting them is part of popular culture.

California Grunion runs are highlighted in public education programs of public aquariums and California State Beaches, and for youth organizations such as the Boy Scouts. Because runs follow the highest spring tides of full or new moons, likely nights and times can be forecast (Walker, 1952; Spratt, 1986). Runs can be dazzling, with thousands of fish moving out of waves onto shore for an hour or more.

Because of its beach-spawning habits, California Grunion has been identified as a Key Indicator Species for the South and Central regions of California Marine Protected Area (Marine Protected

Area Monitoring Action Plan, 2018), and as an indicator species for climate change on beaches in the Ventura County Coastal Resilience Plan (https://www.vcrma.org/vc-resilient-coastal-adaptation-project).

Population status of California Grunion:

Traditional fishery methods cannot be used for stock assessments of California grunion. This species has never been abundant (Gregory, 2001). It is planktivorous (Higgins and Horn, 2014) and does not take a hook. Adults are rarely caught in trawl surveys except within enclosed bays (Allen et al., 2002; Martin et al., 2013; Williams et al., 2016). The only time California grunion can reliably be observed is during their spawning runs.

Runs may occur when tides are suitable, within a two-hour window following the highest nightly tide in four nights after full and new moons in spring and summer. However, often on nights when runs are forecast, no grunion are seen on shore (Martin et al., 2019).

Volunteer citizen scientists, the Grunion Greeters, report observations of spawning runs on beaches all along the California Coast. With reports across the habitat range over two decades (Martin et al., 2007, 2011), this long-term dataset can discern broad trends in population, in order to guide conservation of this endemic species. Grunion Greeters assess the number of fish on shore, the length of shoreline involved, and the duration of the spawning run at its peak with a metric, the Walker Scale, which ranges from W0 (no fish) to W5 (fish covering the shore).

Over 4500 Grunion Greeters have provided over 5000 reports in the past two decades. This compilation is the most complete dataset for this species in existence, both in terms of geographic coverage and duration of observations. Reports come from the entire habitat range, over 50 beaches in California and Baja California, Mexico. A range extension for spawning runs was discovered in 2002 in San Francisco Bay (Johnson et al., 2009), followed by a northward range extension to Tomales Bay in 2005 (Roberts et al., 2007).

Concerns raised by reports from Grunion Greeters:

Large spawning runs still occur, but smaller grunion runs are much more common than in past. Spawning on shore has declined significantly across much of the habitat range in the past fifteen years. This pattern is consistent for this endemic fish across the three coastal counties constituting its core habitat (San Diego, Orange, and Los Angeles), and also on individual beaches known historically for large grunion runs (Martin et al., 2019).

California grunion appear to be shifting habitat range northward to some extent (Martin et al. 2013; Martin et al., 2019). The shift in habitat comes at the cost of smaller adult size and reduced number of eggs, as well as a shorter spawning season (Johnson et al., 2009).

Noisy activities of recreational grunion hunters on shore disrupt spawning runs, preventing fish from reproducing before capture. Poaching during closed season is common on some urban beaches, reported in about 20% of closed season observations. Collection of spawning fish is nearly universal during open season, identified in 90% of open season reports, disrupting runs and preventing reproduction while removing ripe adults from the population (Martin et al., 2019). Regulations are rarely and unevenly enforced, in part because spawning runs always occur in the dark of night.

Many grunion hunters do not fish for any other species, and do not possess fishing licenses. Thus the potential number of people hunting California Grunion is far greater than the 2.5 million sport fishing licenses that were sold in California in 2016.

The occasional presence of large spawning aggregations may create the illusion of abundance even when a population is depleted (Erisman et al., 2011). Occasional large runs may tempt resource managers to believe that these kinds of runs are both more common and more widespread geographically than is the actual situation (Sadovy and Domeier, 2005).

We suggest it is possible that the numbers of adult fish could drop too low for successful spawning even when some members of the species are present and ripe. Runs with fewer than a hundred individuals usually do not include spawning events or egg deposition. Small numbers of fish in a run indicate unsuccessful reproduction. The consistent pattern of decline in median run size is of great concern for this beach-spawning species.

The sister species, the Gulf Grunion *Leuresthes sardina*, endemic to the northern Gulf of California (Bernardi et al., 2003), shares the beach-spawning habits of *L. tenuis* (Thomson and Muench, 1976). The Gulf Grunion appears on the IUCN Red List as "Near Threatened" because of potential habitat loss and human interference. (Findlay et al., 2010). Our California Grunion may face even greater threats than the Gulf Grunion because of larger human populations and more coastal development in California compared with Mexico.

Recommendations for change:

Although this managed species enjoys some unique protections, fishing regulations have not changed since 1949, while fishing pressure has increased.

We strongly encourage increased protection for this charismatic indigenous endemic marine fish.

- Section 28.00, seasonal closure, may be taken June 1 – March 31→ change seasonal closure to include June; may be taken July 1 – March 31 south of Pt. Conception. North of Pt. Conception, seasonal closure, may be taken September 1 – March 31.

Change requested: For the southern population, return seasonal closure April - June, as originally designated in 1927. For the *L. tenuis* north of Pt. Conception, shift the timing of the seasonal closure, to protect the peak season that occurs later there, closure from April – August.

- Section 27.60(b); no bag limit →change to 27.60 (a), limit of 10 for one species.

Change requested: We recommend a change from no bag limit to a limit of no more than 10 fish.

Section 28.00 cites sections 200, 202 205, 210, 219, and 220 of the Fish and Game Code. Section 200 is relevant as this is not a commercial take. Section 202 was repealed Stats 2016. Section 205 is relevant as it allows the Commission to change or abolish an open season and to establish or change a bag limit. Section 210 is repealed Stats 2016. Section 219 is relevant as it provides the Commission authority to act to protect fish, wildlife, and natural resources. Section 220 is repealed Stats 2016.

References Cited

Allen L. G., Findlay A. M., Phalen C. M. 2002. Structure and standing stock of the fish assemblages of San Diego Bay, California from 1994 to 1999. *Bulletin Southern California Academy of Sciences,* 101: 49-85.

Barnhart P. S., 1918. The spawning of the little-smelt *Leuresthes tenuis* (Ayres). *California Fish & Game,* 4: 181-182.

Bernardi G., Findley L., Rocha-Olivares A. 2003. Vicariance and dispersal across Baja California in disjunct marine fish populations. *Evolution*, 57: 1599–1609.

Clark F. N. 1926. Conservation of the grunion. *California Fish & Game,* 12(4): 163-166.

Clark F. N. 1938. Grunion in southern California. *California Fish & Game,* 24(1): 49-54.

Defeo O., McLachlan A., Schoeman D. S., Schlacher T.A., Dugan J., Jones A., Lastra M., Scapini F. 2009. Threats to sandy beach ecosystems: a review. *Estuarine, Coastal and Shelf Science,* 81: 1-12.

Dugan J. E., Hubbard D. M., Rodil I. F., Revell D. L., Schroeter S. 2008. Ecological effects of coastal armoring on sandy beaches. *Marine Ecology,* 29: 160-170.

Erisman B. E., Allen L. G., Claisse J. T., Pondella D. J. II, Miller E. F., Murray J. H. 2011. The illusion of plenty: hyperstability masks collapses in two recreational fisheries that target fish spawning aggregations. *Canadian Journal of Fisheries and Aquatic Science,* 68(10): 1705-1716.

Findley L., Espinosa H., Collette B., Rojas P., 2010. *Leuresthes sardina*. *The IUCN Red List of Threatened Species* 2010: e.T183267A8083578. http://dx.doi.org/10.2305/IUCN.UK.20103.RLTS.T183267A8083578.en.

Gregory P. A. 2001. Grunion. Pp. 246-247 in *California's Living Marine Resources: A Status Report* (Leet W. S., Dewees C. M., Klingbeill R., Larson E. J., Eds.). California Department of Fish and Game, Sacramento, CA, 592 pp.

Higgins B. A. Horn M. H. 2014. Suction among pickers: Jaw mechanics, dietary breadth and feeding behavior in beach-spawning *Leuresthes* spp compared with their relatives. *Journal of Fish Biology,* 84: 1689-1707.

Johnson P. B., Martin K. L., Vandergon T. L., Honeycutt R. L., Burton R. S., Fry A. 2009. Microsatellite and mitochondrial genetic comparisons between northern and southern populations of California Grunion *Leuresthes tenuis*. *Copeia,* 2009: 467-476.

Marine Protected Area Monitoring Action Plan. California Department of Fish and Wildlife and California Ocean Protection Council, California, USA. October 2018. https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Management/Monitoring/Action-Plan

Martin K. L. M. 2015. *Beach-Spawning Fishes: Reproduction in an Endangered Ecosystem*. Oxford, UK: Taylor & Francis Group, CRC Press, 219 pp.

Martin K. L. M., Hieb K. A., Roberts D. A. 2013. A southern California icon surfs north: Local ecotype of California Grunion *Leuresthes tenuis* (Atherinopsidae) revealed by multiple approaches during temporary habitat expansion into San Francisco Bay. *Copeia,* 2013: 729-730. DOI: 10.1643/CI-13-036.

Martin K. L. M, Moravek C. L., Martin A. D., Martin R. D. 2011. Community based monitoring improves management of essential fish habitat for beach-spawning California Grunion. *Sandy Beaches and Coastal Zone Management: Proceedings of the Fifth International Symposium on Sandy Beaches*, Rabat, Morocco. Travaux de l' Institut Scientifique 2011 (6): 65-72.

Martin, K. L. M., Pierce, E. A., Quach, V. V., Studer, M. 2019. Population trends of California's beach-spawning grunion *Leuresthes tenuis* monitored by citizen scientists. *ICES Journal of Marine Sciences* 76 (in press), doi: 10.1093/icesjms/fsz086.

Martin K., Speer-Blank T., Pommerening R., Flannery J., Carpenter K. 2006. Does beach grooming harm grunion eggs? *Shore & Beach,* 74: 17-22.

Martin K., Staines A., Studer M., Stivers C., Moravek C., Johnson P., Flannery J. 2007. Grunion Greeters in California: Beach-spawning fish, coastal stewardship, beach management and ecotourism. Pp. 73-86 *Proceedings of the 5th International Coastal & Marine Tourism Congress: Balancing Marine Tourism, Development and Sustainability*. Ed. by Lück M., Gräupl A., Auyong J., Miller M. L., Orams M. B. Auckland, New Zealand: New Zealand Tourism Research Institute.

Robbins E. 2006. *Essential Fish Habitat in Santa Monica Bay, San Pedro Bay, and San Diego Bay: A Reference Guide for Managers*. MS Thesis, Duke University, 129 pp.

Roberts D., Lea R. N., Martin K. L. M. 2007. First record of the occurrence of the California Grunion, *Leuresthes tenuis***,** in Tomales Bay, California; a northern extension of the species. *California Fish & Game,* 93:107-110.

Sadovy Y., Domeier M. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. *Coral Reefs,* 24(2): 254–262.

Sandrozinski A. 2013. California Grunion. *Status of the Fisheries Report, an Update Through 2011*. California Department of Fish & Wildlife, Sacramento, CA.

Schoeman D. S., Schlacher T. A., Defeo O. 2014. Climate-change impacts on sandy-beach biota: crossing a line in the sand. *Global Change Biology,* 20(8): 2383-2392.

Spratt J. D. 1986. The amazing grunion. *Marine Resource Leaflet No. 3,* California Department of Fish and Game, Sacramento, California.

Thompson W. F. 1919. The spawning of the grunion (*Leuresthes tenuis*). *California Fish & Game,* 5: 1-27.

Thomson D. A., Muench K. A. 1976. Influence of tides and waves on the spawning behavior of the Gulf of California grunion**,** *Leuresthes sardina* (Jenkins and Evermann). *Bulletin of the Southern California Academy of Science,* 75: 198-203.

Ventura County Coastal Resilience Plan. 2018. https://www.vcrma.org/vc-resilient-coastal-adaptation-project

Vitousek S., Barnard P. L., Limber P., Erikson L., Cole B. 2017. A model integrating longshore and cross-shore processes for predicting long-term shoreline response to climate change. *JGR Earth Surface,* 122: 782-806. https://doi.org/10.1002/2016JF004065

Walker B. W. 1949. *The periodicity of spawning by the grunion, Leuresthes tenuis***,** *an atherine fish*. Doctoroal Dissertation, University of California, Los Angeles.

Walker B. W. 1952. A guide to the grunion. *California Fish & Game,* 38: 409-420.

Williams J. P., Pondella D. J. II, Williams C. M., Robart M. J. 2016. *Fisheries Inventory and Utilization Study to Determine Impacts from El Niño in San Diego Bay, San Diego, California for Surveys conducted in April and July 2016*. Unified Port of San Diego, San Diego, CA.

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Tracking Populations of California Grunion: Petition for Change

Dr. K. L. M. Martin,
Pepperdine University,

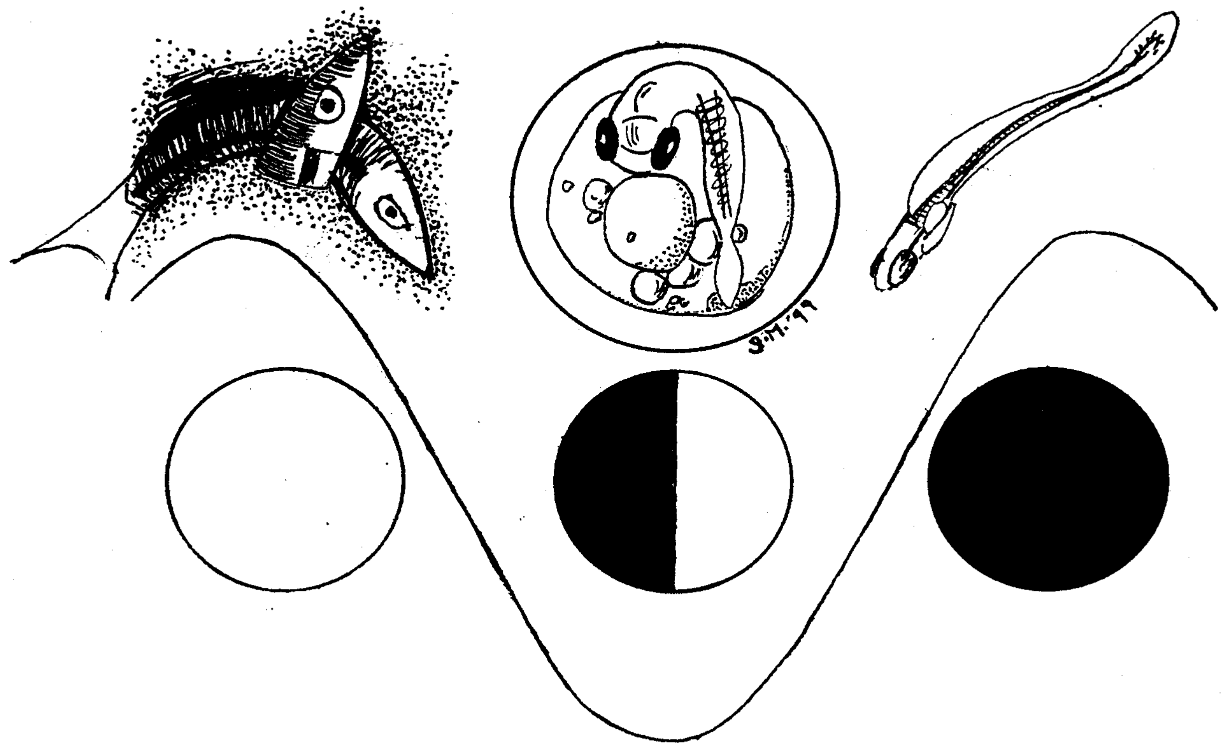
With citizen science data from the Grunion Greeters

Photo: Carl Manaster, Grunion.org

CA Grunion life cycle

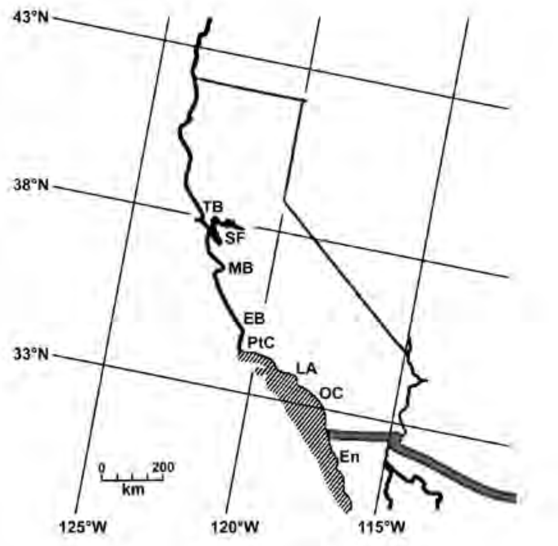
Leuresthes tenuis

- Endemic species, only in California and Baja California, Mexico.
- Spawn on sandy beaches during high tides, after full or new moons.
- Eggs incubate out of water under sand until the next semilunar tides.
- Larvae hatch with rising tides.



Art by G. Martin

CA Grunion: CDFW Managed Species



This indigenous endemic marine fish occurs mainly off the coast of three counties: San Diego, Orange, and Los Angeles.

Recently the habitat expanded to a few locations north of Pt. Conception.

CA Grunion have never been abundant.

CA Grunion are vulnerable to recreational overharvest and to other human activities on the shore.

Since 1927, spawning CA Grunion are protected by:

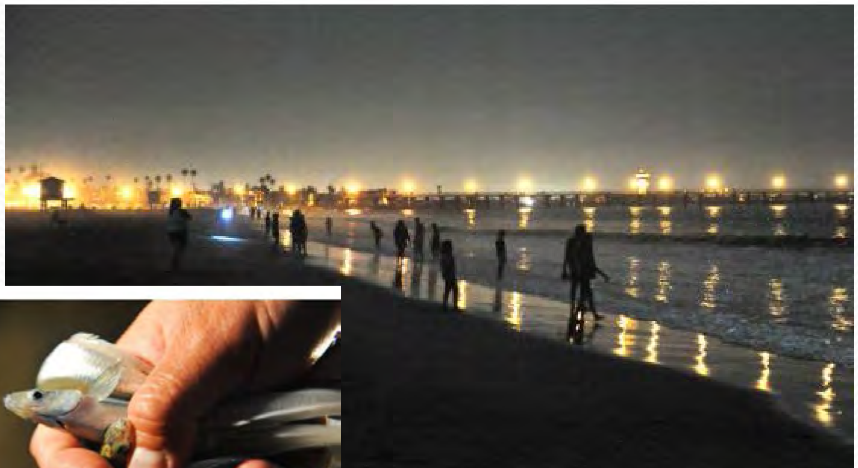


Photo by J. Flannery, M. Reiss, Grunion.org

- Closed season (no take) April and May, originally April - June.
- Gear restrictions (none allowed).
- License requirement for age 16 and above.
- HOWEVER--
- No bag limit.
- No reporting of catch.

The challenges of assessing the stock of *L. tenuis* are many.

- Traditional fishery sampling methods don't work.
- CA Grunion are observed only during spawning runs.
  - Runs vary widely over space and time.
  - All runs occur around the same time of night.
  - Runs occur late at night on dark beaches.

Solution: Grunion Greeters!

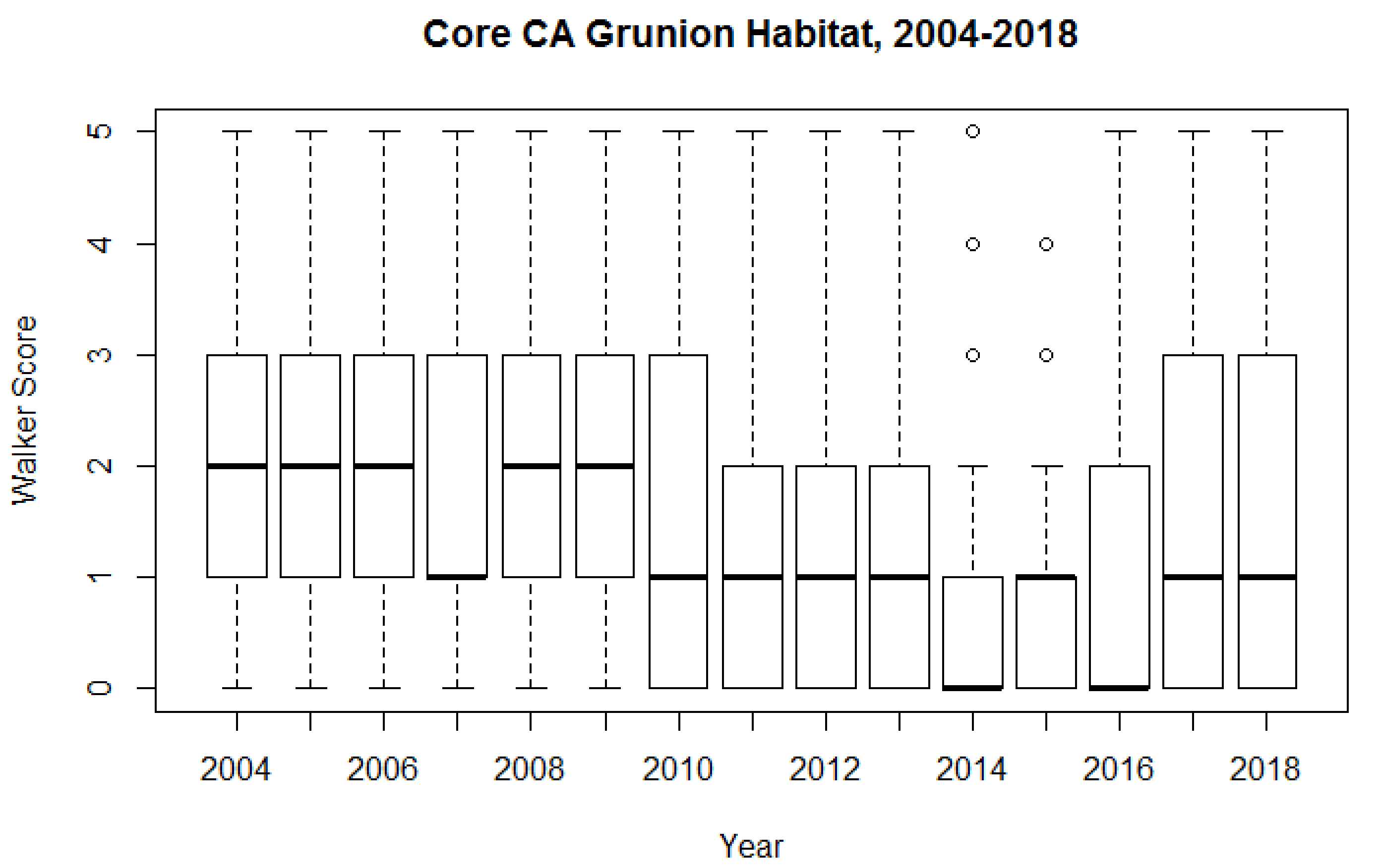
Citizen scientists attend training workshops and monitor specific beaches during nights when grunion runs are forecast.

Walker Scale for Grunion Runs

used by Grunion Greeters

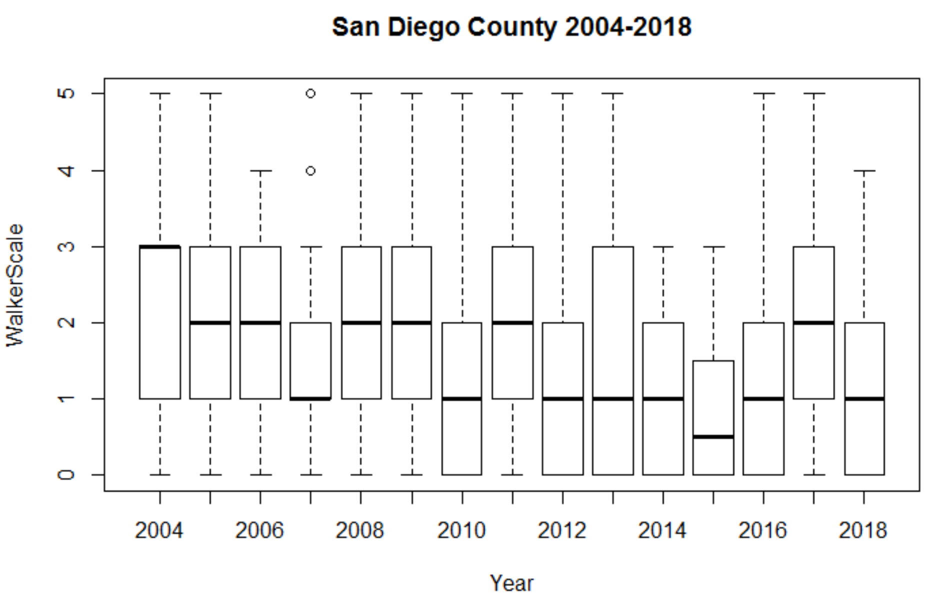
- W-0: No fish show up, or just a few, no spawning.
- W-1: More than 10, and up to 100 fish show up, little or no spawning behavior
- W-2: 100-500 fish; scattered across the beach or in one area, spawning activity
- W-3: several hundred to 1000 fish spawning in one or several locations along the beach
- W-4: thousands of fish spawning across a wide area of the beach
- W-5: fish covering the beach across a wide area, run lasts an hour or more

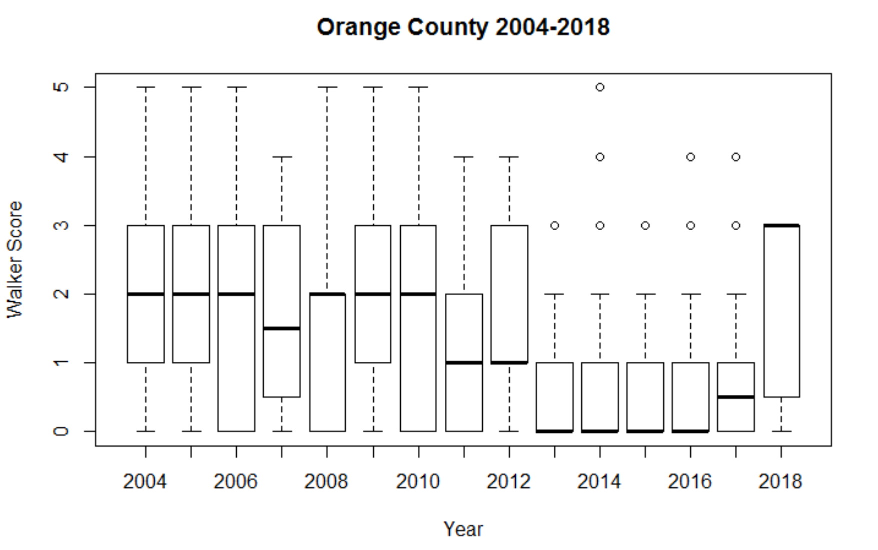
Reports indicate runs have decreased over time in the core species habitat.

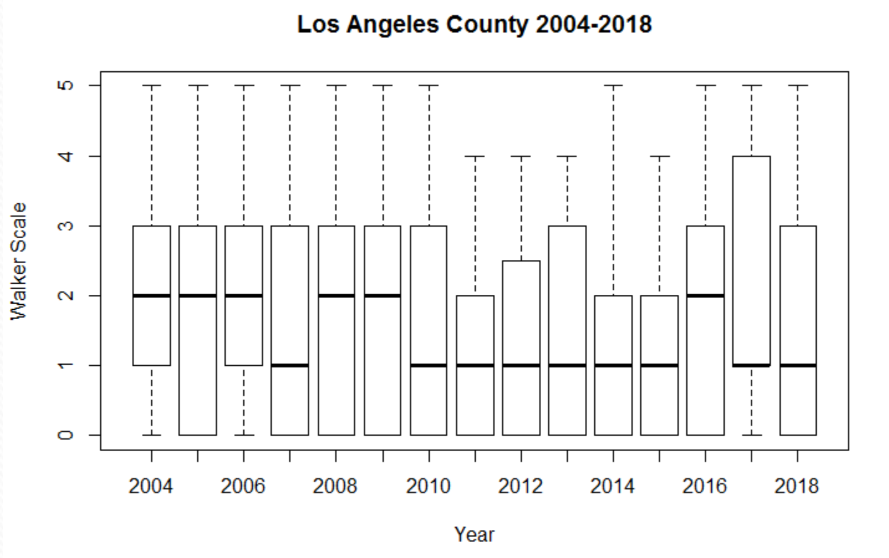


Median run has declined over the past 15 years in San Diego, Orange, and LA counties.

Decline in runs is consistent across each county in the core habitat.

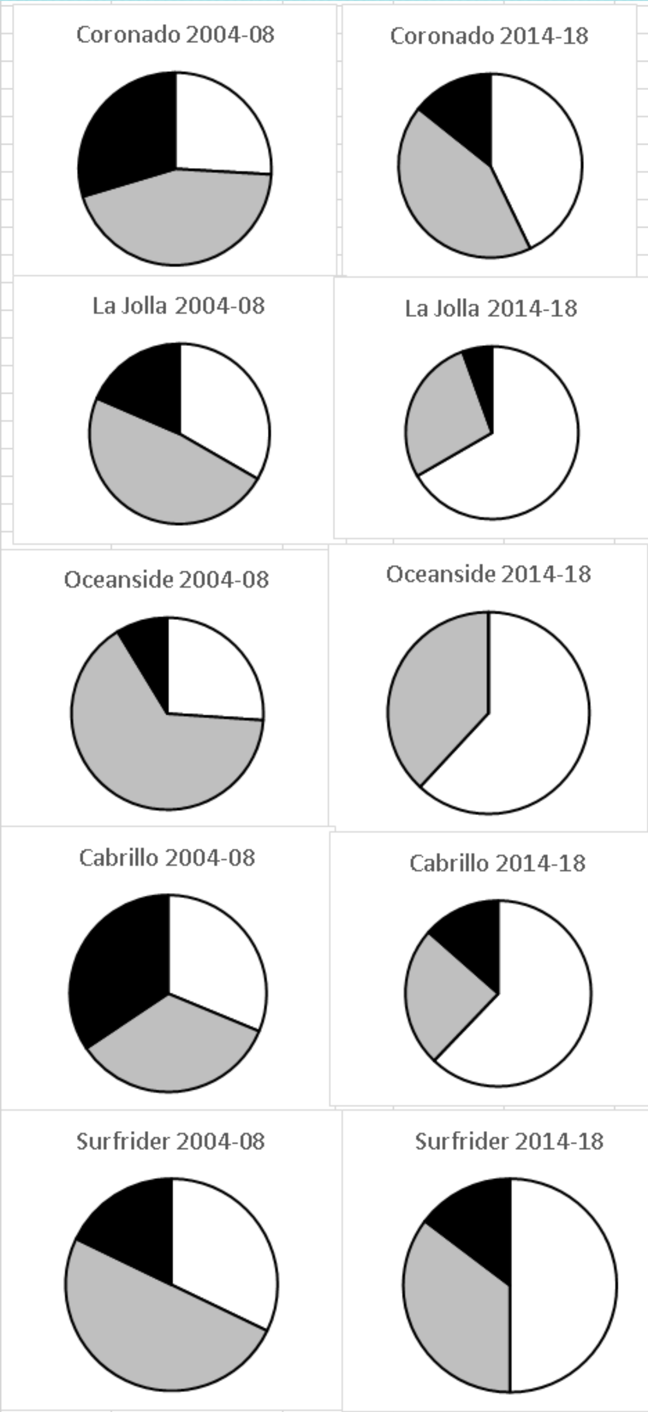




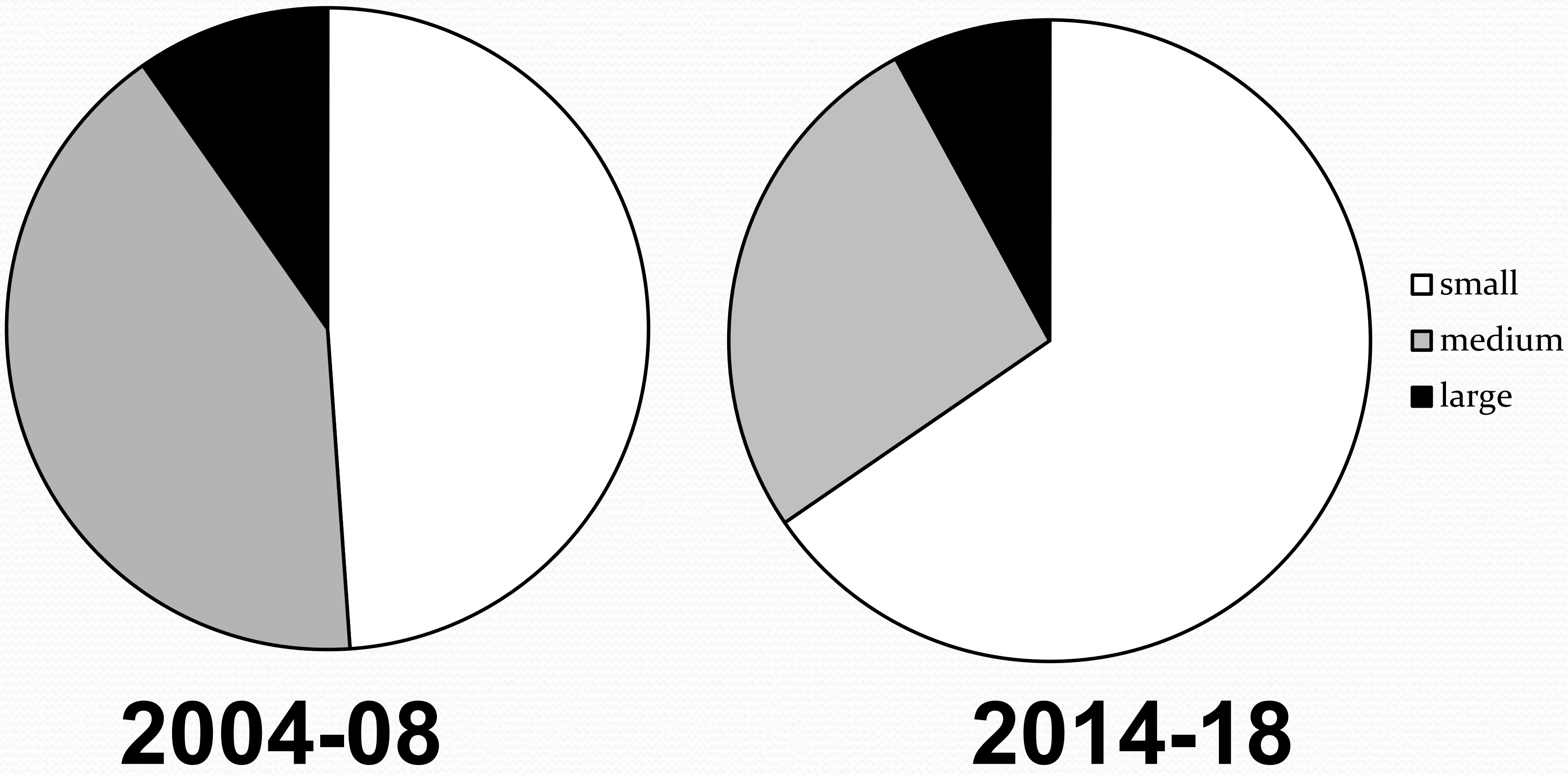


Decline in runs is consistent even at beaches known to hold large runs

White: small, W0-1
Grey: medium, W2-3
Black: large runs, W4-5



Comparison across decades: significantly more small runs, fewer medium and large runs, suggests lower reproductive output.



Poaching (out of season, or using gear in season, or without a fishing license)

In general: poaching in about 20% of reports in Closed Season

Hunting is reported in 93% of observations in Open Season

Regulations are rarely enforced late at night when runs occur.

Grunion spawning zone is small

- Clutches of eggs are buried in a band no more than 3 m wide parallel to shore on busy recreational beaches
- Yes, this is a grunion beach during spawning season.

Northern Grunion are smaller, spawn later, and produce fewer eggs →more vulnerable

Malibu grunion (L)
northern grunion (R)

What actions are needed?

- We recommend changes for the recreational fishery
  - Amend 27.60(b); no bag limit, to 27.60(a), limit 10;
  - Section 28.00, seasonal closure, south of Pt. Conception restore June closure, 7/1 – 3/31.
  - Section 28.00 north of Pt. Conception: later closure, may be taken 9/1 – 3/31.

Photo: Bill Hootkins, 2004

Grunion Greeters THANK YOU FOR YOUR HELP!!!

We encourage

"Observe and Conserve,"

or "Catch and Release"

so that future generations will be

able to marvel at this unique,

charismatic species.

See www.Grunion.org for more

ICES Journal of Marine Science

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Contribution to the Themed Section: '*Marine recreational fisheries - current state and future opportunities*'

Population trends of beach-spawning California grunion *Leuresthes tenuis* monitored by citizen scientists

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California Grunion *Leuresthes tenuis* (Atherinopsidae), an indigenous endemic marine fish, makes spectacular midnight spawning runs onto sandy beaches on the Pacific coast of California and Baja California. In a unique recreational fishery, people capture the fish out of water with bare hands. Grunion hunters are not required to report their catch, and there is no bag limit. California Grunion rarely appear in trawls and do not take a hook, so population status for this species is impossible to obtain by traditional fishery methods. With citizen scientists, the "Grunion Greeters," we monitored spawning runs along most of their habitat range. California Grunion recently underwent a northward range extension, but runs appear to be declining broadly across the core habitat. Noisy activities of recreational grunion hunters on shore disrupt spawning runs, preventing fish from reproducing before capture. *Leuresthes tenuis* has been identified as a Key Indicator Species for the South and Central regions of California Marine Protected Areas, and as an indicator species for climate change on beaches. Gear restrictions, license requirements, and a two-month closed season are rarely enforced late at night. We recommend continued monitoring for *L. tenuis* in California and increased protections for this unique charismatic fish.

Keywords: beach-spawning, citizen science, closed season, endemic species, Atherinopsidae, fishing gear, poaching, recreational fishery, reproduction, spawning run, spawning aggregations.

Introduction

California Grunion *Leuresthes tenuis* (Atherinopsidae) is an indigenous endemic marine fish on the Pacific coast of California. Famous for forming large assemblages that lead to massive runs, individual fish emerge fully out of waves onto beach sand to spawn (Martin, 2015). Runs may last for over an hour following full or new moons in spring and summer, and fish may cover the beach along the water line (see Supplementary Material). In the traditional habitat range of southern California, between Pt. Conception, California and Punto Abreojos, Mexico, spawning season starts in March and may extend into August, peaking between April and June (Clark, 1938; Walker, 1952).

Females dig into the soft wet sand to deposit 1500–3000 eggs while surrounded by males providing milt for external fertilization. Males do not dig into the sand, and may outnumber females by 10 to 1 during the run. Multiple paternity of clutches is typical (Byrne and Avise, 2009), and each male may repeatedly return to shore during a single night's run (Walker, 1949), providing milt for multiple females with a muscular genital papilla (Aryafar *et al.*, 2019). Thus, multiple waves may carry hundreds of the same individuals over and over again. Females spawn once during a series but can spawn multiple times across the season (Clark, 1925; Walker, 1949). The number of fish on shore cannot be easily counted during a large run, but the density, duration, and extent of the fish are far greater during some runs than others (Walker, 1949; Martin *et al.*, 2007).

Leuresthes tenuis is targeted by a unique recreational fishery, solely during these spawning runs (Spratt, 1986; Sandrozinski, 2013). Because of their unusual life cycle, California Grunion are particularly vulnerable to overharvest. Less than 10 years after the first published scientific description of their spawning behaviour (Barnhart, 1918; Thompson,1919), the first regulations to protect them were enacted in 1927 (Clark, 1926, 1938) by the California Department of Fish and Game (now Wildlife), CDFW. At that time, people would line the shore and capture hundreds of grunion with improvised nets made of bed sheets (Andrew Olson, pers. comm.). Early protections included a closure with no take from April to June, the peak of the spawning season, and gear restrictions that specify no gear at all. Only bare hands were (and are) allowed for capturing the fish, presumably to give them a sporting chance while on shore. Those under the age of 16 did not (and still do not) need a fishing license to catch grunion during the open season.

Walker (1949) observed grunion runs on Scripps Beach directly following World War II. On the basis of his recommendations, CDFW reduced the closed season to just April and May. Gear restrictions and license requirements remain in place. At that time California's population was substantially smaller, around 10 million, than it is today, with >35 million people living along one of the most extensively populated and urbanized coasts in the world.

During open season there is no bag limit and no requirement to report catch of this species. No commercial use of the species is permitted. Some anglers catch this species for bait, some people catch these small fish to consume whole, but most of those capturing the grunion report they are doing so for the sport, not for any particular use but because it is part of popular culture.

In reality, regulations are rarely enforced, in part because spawning runs always occur in the dark of night. Although this endemic species enjoys some unique protections, regulations have not been changed since 1949.

California Grunion runs are highlighted in public education programs of coastal public aquariums and California State Beaches, and for youth organizations such as the Boy Scouts. Because runs follow the highest spring tides of full or new moons, likely nights and times can be predicted with some success (Walker, 1952; Spratt, 1986). Especially during closed season, observation of runs can be dazzling, with thousands of fish moving out onto shore from waves for an hour or more. Runs may occur when tides are suitable, within a 2-h window following the highest nightly tide in four nights after full and new moons in spring and summer. However, often on nights when runs are forecast, no grunion are seen on shore.

Sandy beaches are critical to *L. tenuis* as essential fish habitat for spawning (Robbins, 2006). However, beaches in California and worldwide are undergoing habitat loss by coastal squeeze (Defeo *et al.*, 2009; Schoeman et al., 2014; Martin, 2015), with sea level rise and erosion encroaching on the beach from the seaward side, and coastal development and shoreline armouring preventing natural retreat of the beach on the landward side (Dugan *et al.*, 2008). Exacerbated by climate change and increasing human population, California is predicted to lose 31–67% of its sandy beaches by the year 2100 under current predictions of sea level rise (Vitousek *et al.*, 2017).

Because of its beach-spawning habits, *L. tenuis* has been identified as a Key Indicator Species for the South and Central regions of California Marine Protected Area (Marine Protected Area Monitoring Action Plan, 2018), and as an indicator species for climate change on beaches in the Ventura County Coastal Resilience Plan (https://www.vcrma.org/vc-resilient-coastal-adaptation-project). However, monitoring for *L. tenuis* is problematic. This species has never been abundant (Gregory, 2001). *Leuresthes tenuis* is planktivorous (Higgins and Horn, 2014); this species does not take a hook. Adults are rarely caught in trawl surveys except within enclosed bays (Allen *et al.*, 2002; Martin et al., 2013; Williams *et al.*, 2016). Recreational fishers are not required to report catch of this species. Thus, traditional fishery methods cannot be used for stock assessments. The only time *L. tenuis* adults can reliably be observed is during their spawning runs.

We developed a group of volunteer citizen scientists, the Grunion Greeters, to report observations of spawning runs on suitable nights all along the California Coast. This started as a way of addressing management issues on sandy beaches, particularly the ecological effects of raking or grooming of beach sand for aesthetic purposes (Martin *et al.*, 2006; Defeo *et al.*, 2009; Dugan and Hubbard, 2010). On the basis of observations and reports across the habitat range over two decades (Martin *et al.*, 2007, 2011), we have become concerned about the status of the California Grunion population as a whole. We hypothesized that this long-term dataset from Grunion Greeter observations would enable us to discern broad trends in population size of this species along its habitat range, in order to guide conservation of this endemic species.

Methods

Metric for spawning run assessment

Strength, duration, and extent of the spawning runs are assessed by a species-specific metric, the Walker Scale, developed in 1999 by the first author with Mike Schaadt and Suzanne Lawrenz-Miller of Cabrillo Marine Aquarium in San Pedro, CA (Table 1). Initially used to compare runs in Malibu with runs in San Pedro, this method was adopted for volunteers in the Grunion Greeter program starting in 2002 (Martin *et al.*, 2007, 2011). The metric was named after Boyd Walker, in honour of his research on the timing of grunion spawning runs, mainly at Scripps Beach in La Jolla, CA. Walker also relied on volunteer observers to assess runs on two nights in 1947 from multiple different beach locations (Walker, 1949), although they used a different metric than ours.

Grunion Greeters were trained in a series of short workshops from 2002 to 2018 to understand the Walker Scale categories and assess the number of fish on shore at the peak of the run, the duration of the peak of the run, and the extent of shoreline involved in the peak of the run. Greeters make other observations about the conditions during a night when a grunion run is forecast, including weather and presence of animal predators or grunion hunters. Observers use an online web portal to input their data, usually within 24 h. The data portal is open to the public, and the questionnaire includes an assessment of the experience of the observer and whether or not they attended previous training workshops. See www.Grunion.org for additional details. Grunion Greeter data focus on closed season, April and May, but also includes reports from open season before and after. Because the Greeters are volunteers, the locations and number of reports are not constant from year to year, however some beaches are more consistently observed, and may be considered sentinel beaches.

Table 1. The Walker Scale for assessment of grunion runs.

Scale	Number of Grunion on shore at the peak of the run	Duration of peak	Descriptor
W0	No fish or only a few, little or no spawning	Up to an hour	Not a run
W1	Up to 100 fish scattered over a wide area of the beach at a time, some spawning	Up to an hour	Light run
W2	100–500 fish spawning over time, many fish ashore with many of the waves	Up to an hour	Good run
W3	Hundreds of fish spawning at once on several areas of the beach, or thousands in one area	Up to an hour or more	Strong run
W4	Thousands of fish together over a broad area, little sand visible between fish at peak of run	Peak lasts minutes up to an hour	Excellent run
W5	Fish covering the beach several individuals deep, a silver lining of the surf over an extensive area, impossible to walk through run without stepping on fish	Peak spawning continues longer than 1 h	Incredible run

Boyd Walker's pioneering research on grunion provided the scientific basis for understanding the periodicity of the spawning runs in California. The Walker Scale, developed by K. Martin, M. Schaadt, and S. Lawrenz-Miller, is a way to assess the spawning run without actually counting the fish, for comparisons across space and time. Observations should start at or before the time of the highest tides on the four nights following a new or full moon, and continue for 2 h as the tide falls. The number of grunion should be assessed at the peak of the run; most runs start small but some may build up over time. At the peak of the run, how many fish are on shore at any given time? Are they on shore over a short or long period of time? Over a small area or a large extent of the beach? How long does the peak spawning aggregation last? (c) Grunion Greeters and Beach Ecology Coalition, used by permission.

Quality control for Grunion Greeter data

All data were evaluated by scientists before use in analysis. Incomplete forms or forms with no identification from the observer were discarded. Forms from dates or times that were unlikely for grunion to run, or from unclear locations were discarded. Grunion Greeters generally work in pairs to provide internal validation. If multiple observer groups on the same run gave different scores, more credence was given to a more experienced, trained observer. Multiple observers on the same run may have different scores because they observed from different locations on the shore; this was evaluated in the reports. Unusual or atypical reports for a location or time are followed up with an e-mail or phone call for additional details. Reports were verified on subsequent days by sampling for presence and density of clutches of eggs in the sand in some but not all cases.

For the purposes of this study and to avoid bias for data from certain beaches that have more frequent observations, we selected for each beach, only the highest Walker score reported from each spawning series (the four-day period following a new or full moon), from our verified data. Thus, a spawning series with few grunion on the first two nights after a full moon but a large run on the third would be represented only by the highest Walker score for that series.

Data were compared by beach location, county, and year using non-parametric statistics. Data from within the primary habitat of southern California, containing over 90% of the species population (Martin et al., 2013; Martin, 2015), were analysed separately from much sparser data for the central coast that followed a northward range extension in 2002 (Roberts *et al.*, 2007; Johnson *et al.*, 2009).

Results

Since 2002, over 4500 Grunion Greeters have provided over 5000 reports. This Grunion Greeter compilation is the most complete dataset for spawning runs of this species in existence, both in terms of geographic coverage and duration of observations. Reports have come from the entire range of the species, over 50 beaches in California and Baja California, Mexico. A northern range extension for spawning runs was discovered in 2002 in San Francisco Bay (Johnson *et al.*, 2009), followed by a northward range extension to Tomales Bay in 2005 (Roberts *et al.*, 2007). Many Grunion Greeters provided multiple observations over several years. Verified data from professional biologists using our methods to observe California Grunion as part of their monitoring efforts for coastal construction projects are also included.

Grunion Greeters reliably report the location of a run and its strength, based on both multiple independent observations of the same run, and on sporadic post-run sampling of beaches for clutches. In 445 runs with multiple observers, there is 87.6% agreement on the ranking of the Walker Scale. Even with disagreement, scores rarely differ more than one rank between observers.

The core of the habitat range is from the border of California and Mexico in San Diego County through Orange County and Los Angeles County through Malibu. From 2002 to 2010, typically the median run strength in this core area was W2, with a small percentage of the runs at W4 or W5 level (Figure 1). Large spawning runs (W4 and W5) have been seen in every year, on occasion. On a year with a low median, the number of large runs is very low as well. Although large runs still occurred in 2018, in 6 of the past 8 years, 75% of the runs have been W2 or lower in the core habitat for this endemic species.

Examining by county, runs in Los Angeles County, Orange County, and San Diego County have decreased in Walker Score over the time of the study (Figure 2). The five years 2004–2008 compared with the five years 2014–2018 show a significant decrease in the Walker Score of runs in the core habitat over time. This decline is consistent whether testing the three core counties together (Figure 1), looking within individual counties in southern California (Figure 2), or comparing across time within individual sentinel beaches (Figure 3). For the three core counties, significant differences are seen in frequencies of large and small runs between decades ($N = 1952$, $X^2 = 18.42$, $df = 5$, $p < 0.01$). By county, these differences are also significant. For San Diego County, $N = 742$, $X^2 = 11.81$, $df = 5$, $p < 0.037$; for Orange County, $N = 500$, $X^2 = 78.12$, $df = 5$, $p < 0.0001$; and for Los Angeles County $N = 465$, $X^2 = 18.5$, $df = 5$, $p < 0.01$).

Runs are highly variable in space and time. Although on a given night one beach may hold a large run, other beaches on the same night or run series may show little activity (Figure 4). The proportion of runs that are small (W0 or W1) has significantly increased over the past 15 years (Spearman Rank Correlation Coefficient $r_s = 0.57$, $df = 13$, $p = 0.025$). For the three counties of San Diego, Orange, and Los Angeles, small runs were 48.9% of reports from five years between 2004 and 2008, and increased to

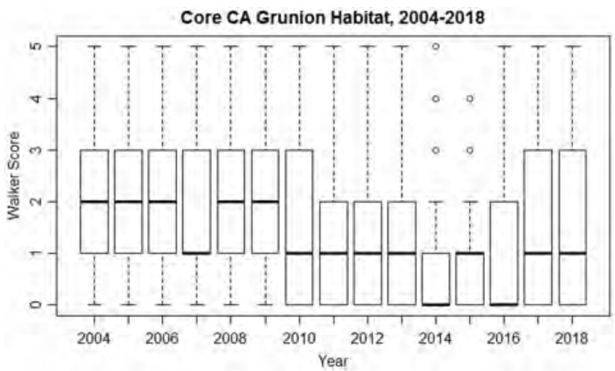

Figure 1. When the Grunion Greeters started, median (heavy bars) run size was a moderate but effective W2 in the core species habitat of southern California. Since 2010, the median of runs reported has been no higher than W1, meaning that at least 50% of the runs observed do not hold significant spawning activity. In two years (2014 and 2016) the median was W0, meaning that >50% of the time runs were predicted, few or no spawning fish were present. From 2011 to 2018, the median across the traditional habitat range typically was W1 and twice was W0. $N = 3462$.

65.4% of reports in the 5 years from 2014 to 2018. The proportion of runs at the W5 level has remained low and fairly consistent over the years, 1.58 ± 0.76% of reports in a given year.

Runs north of the core habitat seem to be increasing according to our reports, although not yet significantly (Figure 5). The areas of northward range extension around San Francisco Bay underwent local extirpation in 2008 (Martin et al., 2013) but have been re-colonized in 2014. Runs in locations in and around San Francisco Bay start later, in May rather than March, and continue into August, with the largest runs usually in July and August.

Grunion Greeters reported poaching (catching out of season, without a license, or with the use of any gear) in ∼20% of reports during closed season, and hunting or poaching for 93% of reports during open season. California fishers are not required to display a license while fishing. Informal questioning indicated that many adults hunting grunion during runs did not purchase a fishing license. Game Wardens were rarely observed during runs, <5 instances out of 5133 reports. Active hunting was often accompanied by loud, raucous crowds and high disturbance and prevention of spawning (Table 2).

Clutches of eggs are buried 10–20 cm deep in beach sand in a band no >1–3 m wide parallel to shore on the upper beach in the mid to high intertidal zone. Considering a narrow strip on average ∼3 m wide along 483 km of sandy beaches in southern California results in a total spawning habitat area of 1.45 km^2 for *L. tenuis* in its core primary habitat at the current time.

Discussion

California Grunion spawning runs can be assessed with the help of citizen scientists; in fact this may be the only way to obtain these extensive, hyperlocal data. The Walker Scale is currently used by professional resource biologists to monitor grunion runs for agencies such as US Army Corps of Engineers, California Department of Fish and Wildlife, California Coastal Commission, National Marine Fisheries Service, and California State Parks, as well as for public educational programs at Cabrillo Aquarium and Birch Aquarium at Scripps, among others (Martin et al., 2011). The Walker Scale is an effective, accurate, non-invasive although labour-intensive method for assessment of this species and other beach-spawning fishes. While the data from professional biologists monitoring grunion runs for coastal projects are certainly reliable, the number, locations, and frequency of these short-term projects are small relative to the substantial, long-term efforts of volunteer Grunion Greeters.

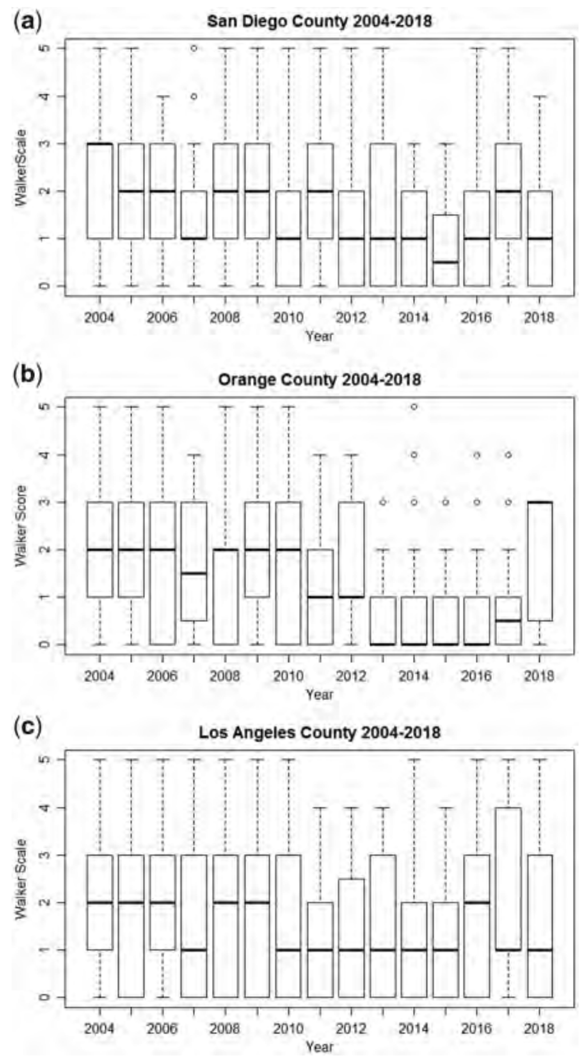

Figure 2. Reports from Grunion Greeters indicate that median (heavy bars) run size based on the Walker Scale have significantly decreased over time for each of the three southern counties. (a) San Diego, (b) Orange, and (c) Los Angeles.

Even though large runs can still be observed, the median Walker Score for California Grunion spawning on shore has declined significantly across much of the core habitat range in the past ten years (Figure 1). This pattern is consistent for this endemic fish across the three coastal counties constituting its core habitat (Figure 2) and within individual beaches known historically for large spawning runs of grunion (Figure 3). The occasional presence of large spawning aggregations may create the illusion of abundance even when a population is depleted (Erisman *et al.*, 2011). These occasional large runs may tempt resource managers to believe that these kinds of runs are both more common and more widespread geographically than is the actual situation (Figure 4, Sadovy and Domeier, 2005).

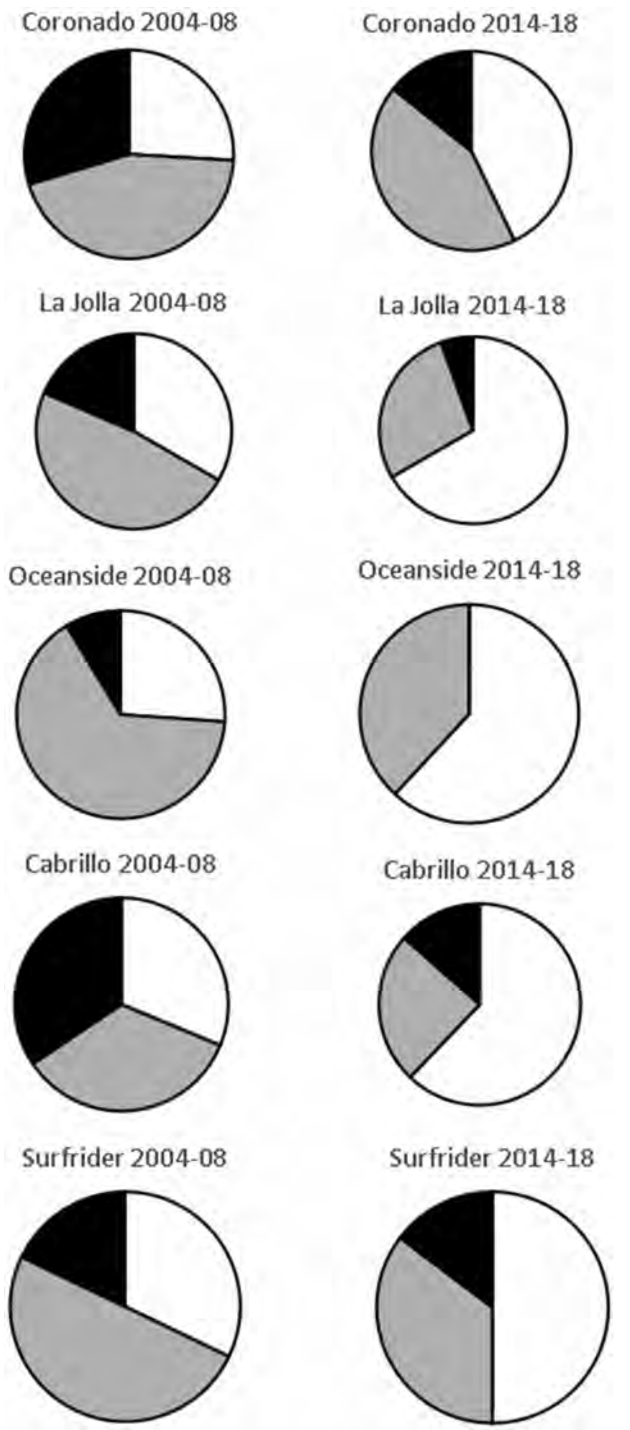

Figure 3. Proportions of runs that are small (W0 or W1), medium (W2 or W3), and large (W4 or W5) in five sentinel beaches in the core habitat range of southern California. Median runs dropped over the past decade and the likelihood of large runs decreased significantly in all cases.

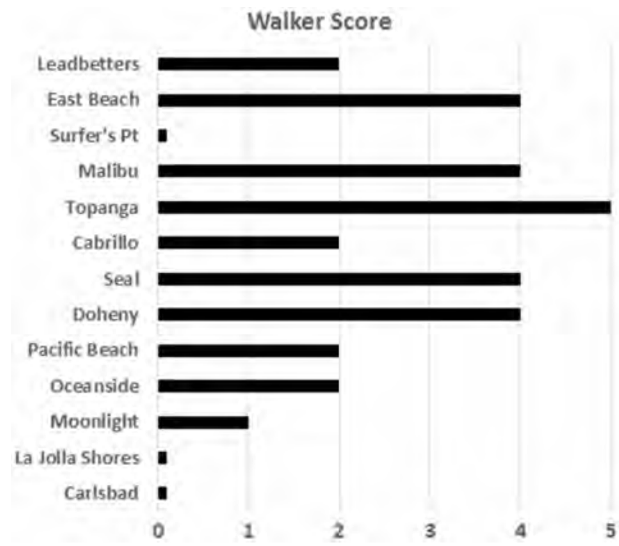

Figure 4. For one April night, beaches from San Diego, Orange, Los Angeles, Ventura, and Santa Barbara counties show the variability in run strength. The median run score is W2 for these 12 beaches.

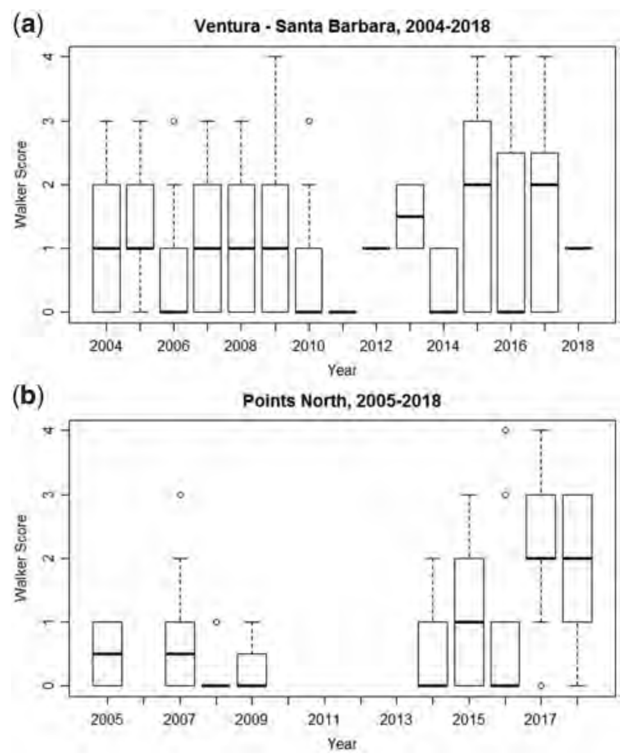

Figure 5. Runs appear to be increasing north of the core habitat range, but these differences are not significant. (a) Ventura and Santa Barbara Counties are north of the core habitat but within the traditional spawning range of *L. tenuis*. (b) *L. tenuis* colonized San Francisco Bay and points north in 2002, and then was locally extirpated by 2008. They returned in 2014 and runs are increasing in strength. Heavy line is median.

On the basis of reports from Grunion Greeters and resource biologists, California Grunion appear to be both shifting their habitat range northward (Figure 5) and decreasing in numbers in the more southern habitats (Figures 1 and 2). Warming trends in ocean water and the atmosphere may be affecting this species (Martin, 2015), along with ocean acidification (Tasoff and Johnson, 2019). There is an environmental component to sex determination of *L. tenuis*, so that warmer temperatures during

Table 2. Grunion Greeter reports indicate high levels of disturbance of spawning by people hunting.

"Unruly THOUSANDS, some in water, all making noise. Looked like some sort of post-apocalyptic marine Mad Max."
"The few grunion that actually came up onto the beach were automatically grabbed by poachers. There were probably 20–30 people taking the fish last night."
"Hundreds of people on beach, many using buckets and strainers to collect fish; informed them of regulations." (report from a marine biologist with California Department of Fish and Wildlife).
"A large group of people gathered at least 10 plastic grocery bags full of grunion and women were walking behind them laughing and kicking the grunion. Many people were taking several hundred grunion home in trash bags."
"Over a hundred people in a frenzy to get the few fish that came in with each wave. Lots of screaming kids, dogs, and flashlights."
"Three families harvested hundreds."
"One goofy guy was running wildly up and down the beach with a flashlight and grabbing at any fish that started to spawn."
"Hunting–Splashing into water, capturing in water or at surf's edge, noisy, yelling, screaming."
"Lots of youngsters excited and splashing in the shallows chasing grunion. Probably they harvested 200 or 300. There were maybe 50+ in groups of 4–10 running to and fro."
"There was a very rowdy group of ~10 people, catching and collecting the grunion during the entire run, yelling and chasing after the fish into the water, up to even waist deep!"
"Bad behavior: Kicking fish, throwing, stepping, or jumping on them."
"TONS of people. At the first big sighting of fish the people rushed the water & the grunion fled."
"There was a pack of ~12–14 non-English speaking people stomping on and kicking fish on the beach. One run of grunion had started and when these people behaved in this way that run went back into the water and did not return to that location."
"Poachers continuously ignored our information very frustrating. Picking them up filling buckets and stepping on them and ripping them in half."
"Fish tried to come ashore but a crazy mob of people lined beach with buckets & lights."

early life result in greater proportions of males (Brown *et al.*, 2014). Of more immediate concern, their critical spawning habitat is also declining (Dugan *et al.*, 2008; Vitousek *et al.*, 2017; King *et al.*, 2018), potentially concentrating the spawning population into fewer locations on shore. The spawning zone of *L. tenuis*, the upper beach between the mid and high intertidal zone (Martin *et al.*, 2006), is also the beach area that is most vulnerable to loss by coastal squeeze (Dugan and Hubbard, 2010; Schooler *et al.*, 2017). The core spawning habitat total area of 1.45 km^2 for *L. tenuis* is smaller than Dodger Stadium or the Los Angeles International Airport. The minimum size is 25 km^2 for one Marine Protected Area (MPA) in California (Botsford *et al.*, 2014), in a network of over 100 MPAs. This critical habitat for *L. tenuis* is likely to decrease, and is already <0.001% of the area of the California MPA network.

Even though the species has managed to shift its habitat and colonize some northern bays, the northern ecotype grows to a smaller adult size, spawns less frequently, and produces significantly fewer, smaller eggs per clutch (Johnson *et al.*, 2009; Martin et al., 2013). For these reasons the northern populations are more vulnerable to ecosystem perturbations and local extirpation than the populations in the traditional habitat. In addition, the more northern populations spawn on a different annual schedule than the southern populations of this species, and therefore the peak run times of the northern populations are not protected by the current closed season of April and May. These northern fish are neither different genetically (Johnson *et al.*, 2009; Byrne *et al.*, 2013) nor are they different in physiological response to temperature (Brown *et al.*, 2012) from the southern grunion, so this habitat shift appears to be restricted to areas of bays that are warmer than the waters of the open ocean.

Fished species that form spawning aggregations face an increased extinction risk (Sadovy and Erisman, 2012). Modern conservation practices almost universally protect the reproductive period and spawning aggregations of species (Hutchings, 2001). The regulations for fishing on California Grunion do the opposite by specifically targeting the spawning aggregations, striking this species at its most vulnerable and critical time, disrupting its ability to produce the next generations. Fishing on large aggregations can mask population declines or collapse (Erisman *et al.*, 2011).

Regulations put in place to protect the endemic California Grunion during spawning runs are rarely and unevenly enforced. Poaching during closed season is common on some urban beaches, and reported during ~20% of closed season observations. Collection of spawning fish by people with or without fishing licenses is nearly universal during open season, identified in the vast majority of open season reports, disrupting runs, and preventing reproduction while removing ripe adults from the population (Table 2). Many grunion hunters do not fish for any other species, and do not possess fishing licenses. Children, not required to have a license, are very effective hunters (see Supplementary Material). Thus the potential number of people hunting California Grunion is far greater than the 2.5 million sport fishing licenses that were sold in California in 2016 (https://www.wildlife.ca.gov/Licensing/Statistics#SportFishingLicenses).

Data from entrainment surveys are the only other long term dataset available for *L. tenuis*. The entrainment data conforms with CalCOFi nearshore trawl data pattern (Miller and McGowan, 2013). For California Grunion, usually less than one, or fewer than two individuals are seen per million cubic meter flow (E. Miller, pers. comm.). Compared with other local silverside fishes, for Topsmelt *Atherinops affinis* 14.6, and Jacksmelt *Atherinopsis californiensis* 39.4 are present per million cubic meters flow at a peak. Both *A. affinis* and *A. californiensis* are fished commercially and recreationally, with hundreds of thousands landed each year (Vejar, 2013). These fishery-independent surveys indicate at a minimum that *L. tenuis* abundance is substantially lower than its sister silverside species of similar size.

Trawl surveys of San Diego Bay (Williams *et al.*, 2016) and San Francisco Bay (Johnson *et al.*, 2009) show large population fluctuations from year to year. In 2016 Williams *et al.* suggested a stock estimate for *L. tenuis* in San Diego Bay of 785,183 fish, but 92% were juveniles in surveys taken during the spawning season. This suggests substantially fewer, only 62,815 adult grunion in

San Diego Bay in 2016. The human population of San Diego's metropolitan area is 3.1 million, http://worldpopulationreview.com/us-cities/san-diego-population/ not including the city's 35 million tourist visitors per year (https://www.sandiego.org/about.aspx).

Because of the tendency of this species to aggregate, we hypothesize that even if fewer fish are present in the total population, large runs will still occur on occasion. Our observations suggest that it is likely that a minimum number of fish must be present for a spawning run to occur. Runs with fewer than a hundred individuals usually do not include spawning events or egg deposition. Therefore the presence of only small numbers of fish during a run suggests unsuccessful reproduction. As runs decline, fewer observations can be made. If the population declines, fewer locations will hold runs, and those runs will occur less frequently. The consistent pattern of decline in median run size is of great concern for this endemic indigenous species. We suggest it is possible that the numbers of adult fish could drop too low for successful spawning even when some members of the species are present and ripe.

The sister species, *Leuresthes sardina* the Gulf Grunion, is endemic to the northern Gulf of California (Bernardi *et al.*, 2003). This species shares the beach-spawning habits of *L. tenuis* (Thomson and Muench, 1976). *Leuresthes sardina* appears on the IUCN Red List as "Near Threatened" because of potential habitat loss and human interference (Findley et al., 2010). The California Grunion *L. tenuis* may face even greater threats because of larger human populations and more coastal development in California compared with Mexico.

In summary, large spawning runs still occur for *L. tenuis*, but smaller runs have been much more common in the present decade than in the previous one in its core habitat range. There may be fewer California Grunion, or the fish may not able to spawn as frequently as in the past. Either way, reproductive output appears to be lower. For those populations that have moved north, the shift in habitat comes at the cost of smaller size and reduced clutch size, as well a shift in spawning season that is shorter and holds less frequent spawning.

We strongly encourage increased protection of the spectacular spawning runs for this charismatic indigenous endemic marine fish. Its status as a managed species and an indicator species for climate change warrant greater concern. At minimum, a return to closed season from April to June, as originally designated in 1927, would help protect the southern population from fishing pressure. We recommend that the *L. tenuis* population on the central coast, in Monterey Bay and around San Francisco Bay, should be completely closed to take, as the populations there appear to be too small to withstand any fishing pressure.

Outreach with the Grunion Greeters may help shift public perception of this species and their interaction with its runs. Greeters report with dismay that those hunting *L. tenuis* during its spawning runs exploit the vulnerability of these fish when out of water (Table 2). Unlike typical fishers who respectfully interact with the resource and take no more than they will use, grunion hunters often say they are following some sort of (perhaps misguided) cultural tradition. They scream and yell while running to wildly chase the fish that are trying to spawn. They sometimes step on the fish in their haste, breaking their backs; then toss them into buckets to expire. Instead, we hope that more and more people will come to quietly observe the run spectacle on its own terms, without disturbing the fish, as watchable wildlife. All should be able to simply enjoy the amazing sight of California's original surfers dancing on the beach.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

Acknowledgements

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References

Allen, L. G., Findlay, A. M., and Phalen, C. M. 2002. Structure and standing stock of the fish assemblages of San Diego Bay, California from 1994 to 1999. Bulletin Southern California Academy of Sciences, 101: 49–85.

Aryafar, H., Carrillo, A., Berquist, R., Frank, L. R., and Forsgren, K. 2019. Description of a male genital papilla in the California grunion, a beach-spawning marine silverside fish. Bulletin of the Southern California Academy of Sciences, in press.

Barnhart, P. S. 1918. The spawning of the little-smelt *Leuresthes tenuis* (Ayres). California Fish & Game, 4: 181–182.

Bernardi, G., Findley, L., and Rocha-Olivares, A. 2003. Vicariance and dispersal across Baja California in disjunct marine fish populations. Evolution, 57: 1599–1609.

Botsford, L. W., White, J. W., Carr, M. H., and Caselle, J. E. 2014. Marine protected area networks in California, USA. Advances in Marine Biology, 69: 205–251.

Brown, E. E., Baumann, H., and Conover, D. O. 2012. Absence of countergradient and cogradient variation in an oceanic silverside, the California Grunion *Leuresthes tenuis*. Marine Ecology Progress Series, 461: 175–186.

Brown, E. E., Baumann, H., and Conover, D. O. 2014. Temperature and photoperiod effects on sex determination in *Leurethes tenuis* (fish), Supplement to: temperature and photoperiod effects on sex determination in a fish. Journal of Experimental Marine Biology and Ecology, 461: 39–43.

Byrne, R., and Avise, J. 2009. Multiple paternity and extra-group fertilizations in a natural population of California grunion (*Leuresthes tenuis*), a beach-spawning marine fish. Marine Biology, 156: 1681–1690.

Byrne, R. J., Bernardi, G., and Avise, J. 2013. Spatiotemporal genetic structure in a protected marine fish, the California Grunion (*Leuresthes tenuis*), and relatedness in the genus *Leuresthes*. Journal of Heredity, 104: 521–531.

Clark, F. N. 1925. The life history of *Leuresthes tenuis*, an Atherine fish with tide controlled spawning habits. Contribution No. 51, State Fisheries Laboratory. *Fish Bulletin Number 10*, California State Fish and Game Commission.

Clark, F. N. 1926. Conservation of the grunion. California Fish & Game, 12: 163–166.

Clark, F. N. 1938. Grunion in southern California. California Fish & Game, 24: 49–54.

Defeo, O., McLachlan, A., Schoeman, D. S., Schlacher, T. A., Dugan, J., Jones, A., Lastra, M., *et al.* 2009. Threats to sandy beach ecosystems: a review. Estuarine, Coastal and Shelf Science, 81: 1–12.

Dugan, J. E., Hubbard, D. M., Rodil, I. F., Revell, D. L., and Schroeter, S. 2008. Ecological effects of coastal armoring on sandy beaches. Marine Ecology, 29: 160–170.

Dugan, J. E., and Hubbard, D. M. 2010. Loss of coastal strand habitat in southern California: the role of beach grooming. Estuaries and Coasts, 33: 67–77.

Erisman, B. E., Allen, L. G., Claisse, J. T., Pondella, II, D. J., , Miller, E. F., and Murray, J. H. 2011. The illusion of plenty: hyperstability masks collapses in two recreational fisheries that target fish spawning aggregations. Canadian Journal of Fisheries and Aquatic Science, 68: 1705–1716.

Findley, L., Espinosa, H., Collette, B., and Rojas, P. 2010. *Leuresthes sardina. The IUCN Red List of Threatened Species* 2010: e.T183267A8083578. doi: 10.2305/IUCN.UK.20103.RLTS.T183267A8083578.en.

Gregory, P. A. 2001. Grunion. *In* California's Living Marine Resources: A Status Report, pp. 246–247. Ed. by W. S. Leet, C. M. Dewees, R. Klingbeill and E. J. Larson. California Department of Fish and Game, Sacramento, CA. 592 pp.

Higgins, B. A., and Horn, M. H. 2014. Suction among pickers: jaw mechanics, dietary breadth and feeding behavior in beach-spawning *Leuresthes* spp. compared with their relatives. Journal of Fish Biology, 84: 1689–1707.

Hutchings, J. A. 2001. Conservation biology of marine fishes: perceptions and caveats regarding assignment of extinction risk. Canadian Journal of Fisheries and Aquatic Science, 58: 108–121.

Johnson, P. B., Martin, K. L., Vandergon, T. L., Honeycutt, R. L., Burton, R. S., and Fry, A. 2009. Microsatellite and mitochondrial genetic comparisons between northern and southern populations of California Grunion *Leuresthes tenuis.* Copeia, 2009: 467–476.

King, P. G., Nelsen, C., Dugan, J. E., Hubbard, D. M., and Martin, K. L. 2018. Valuing beach ecosystems in an age of retreat. Shore & Beach, 86: 1–15.

Marine Protected Area Monitoring Action Plan. California Department of Fish and Wildlife and California Ocean Protection Council, California, USA. October 2018. https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Management/Monitoring/Action-Plan

Martin, K. L. M. 2015. Beach-Spawning Fishes: Reproduction in an Endangered Ecosystem. Taylor & Francis Group, CRC Press, Oxford, UK. 219 pp.

Martin, K. L. M., Hieb, K. A., and Roberts, D. A. 2013. A southern California icon surfs north: local ecotype of California Grunion *Leuresthes tenuis* (Atherinopsidae) revealed by multiple approaches during temporary habitat expansion into San Francisco Bay. Copeia, 2013: 729–730.

Martin,K. L. M., Moravek, C. L., Martin, A. D., and Martin, R. D. 2011. Community based monitoring improves management of essential fish habitat for beach-spawning California Grunion. Sandy Beaches and Coastal Zone Management: Proceedings of the Fifth International Symposium on Sandy Beaches, Rabat, Morocco. Travaux de l' Institut Scientifique, 2011: 65–72.

Martin, K., Speer-Blank, T., Pommerening, R., Flannery, J., and Carpenter, K. 2006. Does beach grooming harm grunion eggs? Shore & Beach, 74: 17–22.

Martin, K., Staines, A., Studer, M., Stivers, C., Moravek, C., Johnson, P., and Flannery, J. 2007. Grunion Greeters in California: beach-spawning fish, coastal stewardship, beach management and ecotourism. *In* Proceedings of the 5th International Coastal & Marine Tourism Congress: Balancing Marine Tourism, Development and Sustainability, pp. 73–86. Ed. by M. Lück, J. Gräupl, J. Auyong, M. L. Miller and M. B. Orams. New Zealand Tourism Research Institute, Auckland, New Zealand.

Miller, E. F., and McGowan, J. A. 2013. Faunal shift in southern California's coastal fishes: a new assemblage and trophic structure takes hold. Estuarine, Coastal and Shelf Science, 127: 29–36.

Robbins, E. 2006. *Essential Fish Habitat in Santa Monica Bay, San Pedro Bay, and San Diego Bay: A Reference Guide for Managers.* MS thesis, Duke University, 129 pp.

Roberts, D., Lea, R. N., and Martin, K. L. M. 2007. First record of the occurrence of the California Grunion, *Leuresthes tenuis*, in Tomales Bay, California; a northern extension of the species. California Fish & Game, 93: 107–110.

Sadovy, Y., and Domeier, M. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. Coral Reefs, 24: 254–262.

Sadovy, Y., Erisman, B. E., 2012. The social and economic importance of aggregating species and the biological implications of fishing on spawning aggregations. *In* Reef Fish Spawning Aggregations: Biology, Research and Management Edition, pp. 225–284. Ed. by Y. Sadovy de Mitcheson and P. Colin. Springer, New York. doi:10.1007/978-94-007-1980-4_8

Sandrozinski, A. 2013. California Grunion. Status of the Fisheries Report, an Update Through 2011. California Department of Fish & Wildlife, Sacramento, CA.

Schoeman, D. S., Schlacher, T. A., and Defeo, O. 2014. Climate-change impacts on sandy-beach biota: crossing a line in the sand. Global Change Biology, 20: 2383–2392.

Schooler, N. K., Dugan, J. E., Hubbard, D. M., and Straughan, D. 2017. Local scale processes drive long-term change in biodiversity of sandy beach ecosystems. Ecology and Evolution, 7: 4822–4834.

Spratt, J. D. 1986. The amazing grunion. *Marine Resource Leaflet No. 3*, California Department of Fish and Game, Sacramento, California.

Tasoff, A. J., and Johnson, D. W. 2019. Can larvae of a marine fish adapt to ocean acidification? Evaluating the evolutionary potential of California Grunion (*Leuresthes tenuis*). Evolutionary Applications, 12: 560–571.

Thomson, D. A., and Muench, K. A. 1976. Influence of tides and waves on the spawning behavior of the Gulf of California grunion, *Leuresthes sardina* (Jenkins and Evermann). Bulletin of the Southern California Academy of Science, 75: 198–203.

Thompson, W. F. 1919. The spawning of the grunion (*Leuresthes tenuis*). California Fish & Game, 5: 1–27.

Vejar, A. 2013. Silversides. Status of the Fisheries Report, an Update through 2011. California Department of Fish & Wildlife, Sacramento, CA.

Vitousek, S., Barnard, P. L., Limber, P., Erikson, L., and Cole, B. 2017. A model integrating longshore and cross-shore processes for predicting long-term shoreline response to climate change. JGR Earth Surface, 122: 782–806. https://doi.org/10.1002/2016JF004065

Walker, B. W. 1949. The Periodicity of Spawning by the Grunion, Leuresthes tenuis, an Atherine Fish. Doctoral dissertation, University of California, Los Angeles.

Walker, B. W. 1952. A guide to the grunion. California Fish & Game, 38: 409–420.

Williams, J. P., Pondella, II, D. J. , Williams, C. M., and Robart, M. J. 2016. Fisheries Inventory and Utilization Study to Determine Impacts from El Niño in San Diego Bay, *San Diego*, California for Surveys conducted in April and July 2016. Unified Port of San Diego, San Diego, CA.

Handling editor: Howard Browman

Decision Summary Document

Pacific Fishery Management Council

September 13-18, 2019

Council Meeting Decision Summary Documents are highlights of significant decisions made at Council meetings. Results of agenda items that do not reach a level of highlight significance are typically not described in the Decision Summary Document. For a more detailed account of Council meeting discussions, see the Council meeting record and transcripts or the Council newsletter.

Habitat

Current Habitat Issues

The Council approved submitting a letter to the United States Forest Service/Bureau of Land Management commenting on essential fish habitat impacts of the Jordan Cove pipeline project.

The Council also requested that the Habitat Committee draft a comment letter to the Bureau of Reclamation on the Central Valley Project/State Water Project, and a letter encouraging the Klamath River Renewal Corporation in their Klamath dam removal efforts, both for the November briefing book. Finally, they directed the Habitat Committee to track the Ventura Shellfish Project.

Ecosystem-Based Management

Fishery Ecosystem Plan (FEP) Five-Year Review

The Council adopted for public review the following vision statement for the FEP:

The Council envisions a CCE [California Current Ecosystem] that continues to provide ecosystem services to current and future generations—including livelihoods, fishing opportunities, and cultural practices that contribute to the wellbeing of fishing communities and the nation.

The Council also adopted for public review a revised set of goals and objectives, which are found in Agenda Item E.1.a, EWG Report 1, September 2019, beginning on page 9 of the report.

In March 2020 the Council will finalize revisions to FEP chapters 1 and 2, including the vision statement and goals and objectives.

Salmon Management

Methodology Review - Final Topic Selection

The Council approved three topics for methodology review: (1) Conduct the technical analysis needed to inform a change of the salmon management boundary line from latitude 40° 05' (Horse Mountain, California) five miles north to latitude 40° 10'; (2) Examine the data and models used to forecast impacts on Columbia River summer Chinook to determine whether a change in methodology is warranted; and (3) Provide documentation of the abundance forecast approach used for Willapa Bay natural coho.

Rebuilding Plans - Final Action

The Council adopted rebuilding plans for Strait of Juan de Fuca natural coho, Queets River natural coho, and Snohomish River natural coho; choosing a final preferred alternative for recommendation to the U.S. Secretary of Commerce. For the Strait of Juan de Fuca natural coho and Queets River natural coho, Alternative I (status quo) was adopted as the final preferred alternative. Alternative II (buffered S_{MSY}) was adopted as the final preferred alternative for the Snohomish River natural coho.

Review of Annual Management Cycle

The Council tasked Council staff and National Marine Fisheries Service staff to develop a work plan and timeline for a potential amendment to the Pacific salmon fishery management plan that would modify the annual salmon management cycle consistent with the proposals requested by National Marine Fisheries Service. The workgroup will report back to the Council at the November 2019 Council meeting.

Pacific Halibut Management

2020 Catch Sharing Plan and Annual Regulations

The Council adopted for public review proposed changes to the 2020 Area 2A Catch Sharing Plan (CSP) and annual fishing regulations in Washington and Oregon recreational fisheries. No changes were proposed for California recreational fisheries.

Washington Department of Fish and Wildlife proposed three changes for public review:

1. Puget Sound sub-area: Provide flexibility for this sub-area to open in April.
2. North Coast, South Coast, and Columbia River Subareas: In years when April 30 falls on a Thursday, provide flexibility for the season to open on April 30.
3. All Washington Subareas: Revise the current CSP language to provide the flexibility to open up to three days per week.

Oregon Department of Fish and Wildlife proposed five changes for public review:

1. Oregon Coastwide: Allow All-Depth Halibut Fishing and Longleader Gear Fishing on the Same Trip (*Status quo: Longleader gear fishing not allowed on the same trip as all-depth halibut, Alternative 1: Allow longleader gear fishing on the same trip as all-depth halibut)*.
2. Columbia River and Southern Oregon Subareas: Revise the Southern Oregon Subarea Allocation (*Status quo: The Southern Oregon Subarea allocation is 3.91 percent of the Oregon sport allocation. Alternative 1: The Southern Oregon Subarea allocation is 3.91*

percent of the Oregon sport allocation up to a maximum of 8,000 pounds. Any poundage over that will be allocated to the Columbia River Subarea).

3. Central Coast Subarea: Revise the start date of the nearshore fishery (*Status quo: Opens June 1, seven days per week Alternative 1: If the Central Coast Nearshore fishery allocation is 25,000 pounds or greater, the season will open May 1; if the allocation is less than 25,000 pounds the season will open June 1*).
4. Central Coast Subarea: Revise the days per week open in the summer all-depth fishery (*Status quo: Open the first Friday and Saturday in August, then every other Friday and Saturday until Oct. 31, or quota attainment. Alternative 1: If the allocation projected to remain in the spring all-depth fishery after its conclusion plus the summer all-depth allocation total 60,000 pounds or more after the spring all-depth season concludes, a third open day may be added to the summer all-depth season open days. Alternative 1a. Thursday will be the additional open day, Alternative 1b. Sunday will be the additional open day*).
5. Central Coast Subarea: Revise the spring all-depth season back-up days (*Status quo: Available back-up days are every other Thursday, Friday, and Saturday. Alternative 1: After the spring all-depth season fixed dates, Oregon Department of Fish and Wildlife, National Marine Fisheries Service, International Pacific Halibut Commission and Council staff can confer and determine if back-up dates can be open every Thursday, Friday, and Saturday*).

Commercial Directed Fishery Regulations for 2020

The Council adopted for public review preliminary recommendations for the 2020 Area 2A non-Indian directed commercial halibut fishery. Two options for fishing duration included 1) status quo (10-hour period) and 2) a five-day fishing period (with reduced vessel limits anticipated). Two options for season start date included: 1) Last Wednesday in June (status quo), and 2) Last Wednesday in May.

Groundfish Management

Workload and New Management Measure Update

The Council heard from their groundfish advisory bodies and the Salmon Advisory Subpanel on new proposed management measures, groundfish retention in the salmon fishery, two items relating to the non-trawl Rockfish Conservation Area, and two exempted fishing permits. The Groundfish Management Team provided analyses on conversion factors and the salmon vessel monitoring ping rate as requested by the Council at their June 2019 meeting. After review of all the items, the Council elected not to adjust the current unprioritized list (Table 3), prioritize any new measures, or request analyses of any new measures.

Electronic Monitoring Program Guidelines and Data Storage Procedural Directive: Preliminary Review

The Council recommended that National Marine Fisheries Service consider the suggested changes identified in the Groundfish Electronic Monitoring (EM) Policy Advisory Committee report regarding the EM Program Guidelines and the draft Data Storage Procedural document. The Council will also send a letter to Pacific States Marine Fisheries Commission (PSMFC) requesting PSMFC identify a pathway forward that allows PSMFC to continue providing EM review services for the industry in 2021. The Council is anticipated to review revised Program Guidelines and an EM Manual and further discuss program implementation at the November 2019 Council meeting.

Endangered Species Act Mitigation Measures for Salmon

The Council reviewed the range of alternatives developed in April 2019 for this item and adopted the preliminary preferred alternatives (PPA). Most of the PPAs adopted by the Council mirrored the language found in the Initial Review Draft. The PPAs are shown below and are underlined, with any modifications to the original Alternative noted:

- Block Area Closures: Alternative 1
- Extension of Block Area Closure for All Trawl Gears to the Western Boundary of the Exclusive Economic Zone:
  Alternative 1: Develop regulation to allow for the extension of any block area closure seaward of 250 fathoms south of 46º 16′ 00″ N. latitude (WA/OR border) for all trawl gears to the western boundary of the Exclusive Economic Zone (for midwater trawl) or to the 700 fathom Essential Fish Habitat Conservation Area closure (for bottom trawl).
- Selective Flatfish Trawl Net requirement: Alternative 1
- Pacific Whiting Cooperative Operational Rules Alternative 2:
  Develop regulations to allow each whiting sector co-op to develop salmon mitigation plans for approval by National Marine Fisheries Service (NMFS). Include a requirement for annual season summary reporting to the Council and NMFS describing high-salmon bycatch incident information and avoidance measures taken.
- Automatic Authority for NMFS to Close Trawl Sectors and Preserve 500 Chinook salmon for Fixed Gear and Recreational Fisheries: Alternative 1

Development of Reserve rule provision

- Alternative 1: A sector may only access the Reserve if the Council or NMFS has taken action to minimize Chinook salmon bycatch in that sector prior to it reaching its Chinook salmon bycatch guideline.
  - The requirement for Council or NMFS action to minimize Chinook salmon bycatch for access to the Reserve by the at-sea whiting sectors would be satisfied upon approval by NMFS of each of those sector's respective co-op salmon mitigation plans.
  - The requirement for Council or NMFS action to minimize Chinook salmon bycatch for access to the Reserve by the shoreside whiting sector would be satisfied upon approval by NMFS of that sector's co-op salmon mitigation plans, provided all

participating vessels are members of a shoreside co-op with an approved salmon mitigation plan.
  - If there are vessels participating in the shoreside whiting fishery that are not members of a shoreside whiting co-op, then additional actions by the Council or NMFS may be needed to minimize Chinook salmon bycatch (e.g., Block Area Closures, Selective Flatfish Trawls) prior to allowing access to the reserve by that sector.

Adopt Final Stock Assessments

The Council adopted the assessments, catch-only projections, yelloweye rockfish projections of new acceptable biological catches, and the yelloweye catch report endorsed by the Scientific and Statistical Committee. These assessments and projections of harvest specifications will inform management of the West Coast groundfish fishery in 2021 and beyond.

2020 Harvest Specifications for Cowcod and Shortbelly Rockfish

The Council adopted Purpose and Need statements in consideration of 1) increasing the 2020 annual catch limit (ACL) for shortbelly rockfish and 2) in consideration of eliminating the 2020 annual catch target (ACT) and reducing the yield set-aside for cowcod south of 40° 10' N. lat. as a means of increasing the annual vessel limit of cowcod in the trawl individual fishing quota fishery.

The Council adopted a range of 2020 shortbelly rockfish ACLs from the status quo 500 mt ACL to an ACL of 4,184 mt, which is equal to the 2021 and 2022 acceptable biological catch of shortbelly rockfish. The Council's preliminary preferred alternative for a 2020 shortbelly rockfish ACL is 3,000 mt, as recommended by the Groundfish Advisory Subpanel.

The Council also adopted an alternative to the status quo ACT of 6 mt for cowcod south of 40° 10' N. lat., which would eliminate the ACT. Three options for adjusting the yield set-aside range from no adjustment to the specified set-aside of 2 mt to a 75 percent reduction of the set-aside (0.5 mt). The Council's preliminary preferred alternative for this action is to eliminate the ACT and reduce the set-aside by 50 percent (1 mt). This action would increase the 2020 annual cowcod vessel limit from 858 lbs. to 1,264 lbs.

The Council is scheduled to take final action for both of these initiatives at their November meeting in Costa Mesa, California.

Phased-In Approach to Changing Harvest Limits – Scoping

The Council took no action in consideration of specifying a phased-in approach to changing groundfish harvest limits in the Pacific Coast Groundfish Fishery Management Plan (FMP) at this time. The Council cited the recommendations of the Groundfish Management Team and Groundfish Advisory Subpanel that the workload costs outweigh the potential benefits associated with this action. Further, the Council tasked staff with sending a response letter to the National Marines Fisheries Service forwarding the comments of the Scientific and Statistical Committee on the draft NOAA Technical Memorandum - "National Standard 1 Technical Guidance for Designing, Evaluating, and Implementing Carry-over and Phase-in Provisions within ABC Control Rules."

Initial Harvest Specifications and Management Measure Actions for 2021-2022 Management

The Council adopted the 2021 and 2022 groundfish harvest specifications informed by the overfishing limits, stock categories, and sigma values (to inform new acceptable biological catches) endorsed by the Scientific and Statistical Committee. The Council also recommended exploration of alternative harvest control rules and resulting harvest specifications for cowcod south of 40° 10' N. lat., petrale sole, sablefish, shortbelly rockfish, and Oregon black rockfish.

The Council also requested further comment on new management measures recommended by the California Department of Fish and Wildlife, Groundfish Management Team, and Groundfish Advisory Subpanel.

The Council will consider a range of alternative stock harvest control rules and new management measures for detailed analysis at their November meeting in Costa Mesa, California. The Council is scheduled to decide final 2021 and 2022 groundfish harvest specifications at their April 2020 meeting in Vancouver, Washington and final management measures at their June 2020 meeting in San Diego, California.

Final Action on Inseason Adjustments – Including Final Recommendations on Exempted Fishing Permits for 2020

The Council adopted new sablefish daily trip limits as follows:

- Open Access North: 300 lb/day, or one landing per week up to 1,500 lb, not to exceed 3,000lbs/ 2 months
- Limited Entry North: 1,700 lb/week, not to exceed 5,100 lb/ 2 months

The Council also recommended that the National Marine Fisheries Service extend the midwater trawl and electronic monitoring exempted fishing permits through 2020. The Council also encouraged the National Marine Fisheries Service to consider improvements to the electronic monitoring exempted fishing permits as recommended by the GMT.

Methodology Review - Final Topic Selection

The Council adopted those methodology review topics recommended by the Scientific and Statistical Committee for formal methodology reviews next year. These topics include: 1) a combined visual-hydroacoustic survey of Oregon's nearshore semi-pelagic black, blue, and deacon rockfish as proposed in Agenda Item H.10, Attachment 1; 2) a review of data-moderate approaches that are highly reliant on length data as proposed in Agenda Item H.10, Attachment 2; and 3) a meta-analysis of productivity estimates for elasmobranchs. These methodologies will be reviewed next year and may inform future groundfish stock assessments and management decisions if endorsed.

Highly Migratory Species Management

Recommend International Management Activities

The Council made the following recommendations on U.S. positions for the Permanent Advisory Committee to advise the U.S. Commissioners to the Western Central Pacific Fisheries

Commission:

- Negotiate an equitable allocation of harvest opportunity for Pacific bluefin tuna between the Eastern Pacific Ocean and the Western and Central Pacific Ocean.
- Seek a change in the proportion of Western Central Pacific Fisheries Commission Northern Committee members that must be present for its meeting to achieve a quorum. The current threshold is too high, such that the Northern Committee did not reach a quorum when members met in September 2019.

Exempted Fishing Permits - Final Recommendations

The Council approved the Exempted Fishing Permit application submitted by Mr. Nathan Perez and Mr. Thomas Carson to fish a modified configuration of both standard and linked night-set buoy gear (fishing the gear at night) and recommended that National Marine Fisheries Service issue the permit with a 100 percent observer coverage requirement.

Deep-Set Buoy Gear Authorization – Final Action

The Council adopted its Preliminary Preferred Alternative for authorization of a Deep-Set Buoy Gear Fishery as its Final Preferred Alternative with the following clarifications:

1. Permit issuance is intended to be cumulative, adding 25 permits each year to the prior year total until a maximum of 300 is reached. Any permits issued in previous years that were not issued or renewed would also be available for issuance each year.
2. National Marine Fisheries Service (NMFS) will provide updates to the Council on permit issuance, though the number of additional permits issued by NMFS each year need not be reconsidered nor approved by the Council annually.
3. A cessation or temporary halt ("pause") in permit issuance before 300 permits are issued is possible and would be considered by the Council in order to address concerns identified by NMFS or the Council.
4. The end-date for demonstrated swordfish experience found in the Limited Entry Permit issuance criterion (Suboption 4) number 8 is removed.

The Council also adopted draft proposed FMP amendment language (Amendment 6 to the Highly Migratory Species Fishery Management Plan) with some modest changes.

The Council's preliminary preferred alternative (now final preferred) is described in the Preliminary Draft Environmental Impact Statement as Alternative 3 (see section 2.3 beginning on page 8).

Administrative

Legislative Matters

The Council responded to requests for comments on legislation from Senator Cantwell (S. 2346) and Representative Bishop (HR 1979 and HR 2236).

Membership Appointments; Statement of Organization, Practices, and Procedures; and Council Operating Procedures

The Council appointed Mr. Bob Dooley and Mr. Virgil Moore to the Legislative Committee. Mr. Brian Hooper was appointed to the vacant National Marine Fisheries Service seat on the Groundfish Endangered Species Workgroup and Ms. Erica Crust was appointed to the Washington Department of Fish and Wildlife seat on the Groundfish Management Team formerly held by Ms. Jessi Doerpinghaus.

The Council adopted a final Council Operating Procedure (COP) 22, describing a process to conduct essential fish habitat reviews. The new COP 22 applies to all Council fishery management plans, and establishes a tiered approach, with the expectation that the Council will develop a more detailed approach for each individual essential fish habitat review, upon initiating those reviews.

The Council was informed that Dr. Rishi Sharma and Dr. Aaron Berger have resigned their at-large seats on the Scientific and Statistical Committee (SSC). The Council directed staff to solicit nominations for these two seats between now and the November meeting with a specific request for nominees with expertise in groundfish stock assessment or highly migratory species. The Council also anticipates that long-time SSC member Dr. David Sampson will be retiring at the end of the year and the Council anticipates working with Oregon Department of Fish and Wildlife to fill the Oregon SSC seat he will be vacating.

PFMC
09/23/19
3:18 PM

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
License and Revenue Branch
1740 N. Market Blvd.
Sacramento, CA 95834
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Certified Mail

May 31, 2019

Mr. Darren B. Johnson
[redacted]
Beaver, OR 97108

Subject: **NOTICE OF DENIAL FOR REINSTATEMENT OF SALMON VESSEL PERMIT, PERMIT NUMBER SA0649**

Dear Mr. Johnson:

This letter is in response to your request to reinstate the Salmon Vessel Permit (SVP), Permit Number SA0649, for the F/V *Pacific Rim* (FG71989).

Authority-Salmon Vessel Permit
Fish and Game Code (FGC) Section 8235(a) states that the owner of a permitted vessel, or that owner's agent, may apply for renewal of the permit annually on or before April 30, upon payment of the fees without penalty. Upon receipt of the application and fees, the Department of Fish and Wildlife ("Department") shall issue the permit for use of the permitted vessel in the subsequent permit year only to the owner of the permitted vessel.

Authority-Late Renewal Applications
FGC Section 7852.2(a) establishes a graduated late fee for any renewal application that is received after the deadline.

FGC Section 7852.2(b) states the Department shall not waive the applicable late fee. Additionally, FGC Section 7852.2(c) requires the Department to deny any application for renewal received after March 31 of the permit year following the year in which the applicant last held a valid permit for that fishery.

Reason for Appeal to the Department
In your letter received on April 22, 2019, you are requesting reinstatement of the SVP for the F/V *Pacific Rim*. You explained that you are the new owner of the F/V *Pacific Rim* and were under the impression that the SVP was up to date when you purchased the vessel.

Department Findings
Department license records show that the F/V *Pacific Rim* last held a valid SVP in 2017-2018, which made you eligible to renew the permit for the 2018-2019 permit year.

Department Determination
Based on the previously stated information, your request to reinstate the SVP for the F/V *Pacific Rim* is denied, because the F/V *Pacific Rim* last held a valid SVP in the 2017-2018 permit year. The Department received your request to renew the SVP on April 22, 2019. FGC Section 7852.2(c) requires the Department to deny any application for renewal received after March 31 of the permit year following the year in which the applicant last held a valid permit for that fishery.

Enclosed is voided check #1440 submitted for the license and permit fees.

Deadline to File an Appeal to the Fish and Game Commission
If you wish to appeal the Department's decision, you must submit a written appeal to the Fish and Game Commission (Commission) either by mail at P.O. Box 944209, Sacramento, CA 94244-2090, or by email at fgc@fgc.ca.gov. Pursuant to FGC Section 7852.2(d), your written appeal must be received within 60 days of the date of this letter. The Commission, upon consideration of the appeal, may grant the renewal of the SVP. If the Commission grants the renewal, it shall assess the applicable late fees, which amount to $3,930.73. A fee schedule is enclosed.

If you have any questions or require further assistance, please contact Ms. Ruth Flores at (916) 928-7470 or Ruth.Flores@wildlife.ca.gov.

Sincerely,

Joshua Morgan, Chief
License and Revenue Branch

Enclosure

cc: Ms. Melissa Miller-Henson
Fish and Game Commission
Sacramento, CA

Ms. Ruth Flores
California Department of Fish and Wildlife
Sacramento, CA

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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Mr. Darren B. Johnson
Fees Required for Reinstatement for a
Salmon Vessel Permit (SVP)
Permit Number SA0649
F/V *Pacific Rim* (FG71989)

Prior Year Fees	**Permit Fees**
2018-2019 Non-resident Commercial Fishing License	$ 417.75
Commercial Fishing Salmon Stamp	$ 87.55
Non-resident Commercial Boat Registration	$ 1,087.00
SVP	$ 44.29
Late Fee (61 days to March 31, 2019)	$ 607.75
Prior Year Fees Due	**$ 2,244.34**

Prior year permit fees must be paid before a 2019-2020 SVP can be issued

Current Year Fees	
2019-2020 Non-resident Commercial Fishing License	$ 431.00
Commercial Fishing Salmon Stamp	$ 87.55
Non-resident Commercial Boat Registration	$ 1,122.00
SVP	$ 45.84
Total Current Fees Due	**$ 1,686.39**
Total Fees Due	**$ 3,930.73**

If the Fish and Game Commission should recommend approval, full payment of $3,930.73 would be due.

Fish and Game Commission 7-18-19

California Dept of Fish and Wildlife,

2019 JUL 22 PM 1:31

I Darren Johnson NEW OWNER of the FV Pacific Rim Am writing you Today 7-18-19 to Appeal the Decision of denial of Reinstatement of SVP SA0649, for the F/V Pacific Rim (FG71989).

Please consider the Reinstatement. this misunderstanding Has cost me to miss out on the BEST SEASON in 50 years I'VE Heard, I Put everything I owned into to "Living the Dream". This was an Honest mistake Due to misleading INFO on my Part. IM SORRY and Hope you can Find a way to Reinstate the Permit.

Inclosed is a check for Full Pmt of $3,930.73 if Approval is Recommended. THANKS for your time and SORRY for the confusion on my Part.

THANK You

Darren

7-18-19

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PMT SENT
7-18-19

If the Fish and Game Commission should recommend approval, full payment of $3,930.73 would be due.

DARREN B JOHNSON

7-18-19
Date

Pay to the Order of Dept of Fish and Wildlife $ 3,930.73
Three thousand nine hundred and thirty — 73/100 Dollars

Photo Safe Deposit® Details on back

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Office of the General Counsel
P.O. Box 944209
Sacramento, CA 94244-2090
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

September 10, 2019

California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

Re: *In the Matter of Darren Johnson*

Dear Commissioners:

This letter is in response to Darren Johnson's request to appeal the Department of Fish and Wildlife's ("Department") denial of his request to renew his Salmon Vessel Permit, #SA0649 ("SVP"). The SVP was last valid during the 2017-18 fishing year. Mr. Johnson submitted his appeal request to the Commission on July 18, 2019. The Department will not be participating in this appeal and accordingly, does not object to the renewal of the SVP for the 2019-2020 fishing year, provided that he pays all applicable fees.

The fees that Mr. Johnson must pay to renew the SVP are described in Fish and Game Code, section 7852.2 ("Section 7852.2"), subdivision (a). Section 7852.2, subdivision (a) states:

> (a) In addition to the base fee for the license, stamp, permit, or other entitlement, the department shall assess a late fee for any renewal the application for which is received after the deadline, according to the following schedule:
> (1) One to 30 days after the deadline, a fee of one hundred twenty-five dollars ($125).
> (2) Thirty-one to 60 days after the deadline, a fee of two hundred fifty dollars ($250).
> (3) Sixty-one days or more after the deadline, a fee of five hundred dollars ($500).

To emphasize that these fees must be paid, Section 7852.2, subdivision (b) states that "The department shall not waive the applicable late fee," while subdivision (d) states "If the commission grants renewal, it shall assess the applicable late fee pursuant to subdivision (a)." The fees total **$3,930.73** and are described in the attached fee statement.

If you have any questions please contact me at the address above or by telephone number (916) 651-7646, or e-mail at David.Kiene@wildlife.ca.gov.

Sincerely,

DAVID KIENE
Senior Staff Counsel

Cc: Darren Johnson

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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Mr. Darren B. Johnson
Fees Required for Reinstatement for a
Salmon Vessel Permit (SVP)
Permit Number SA0649
F/V *Pacific Rim* (FG71989)

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Prior year permit fees must be paid before a 2019-2020 SVP can be issued

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Total Fees Due	**$ 3,930.73**

If the Fish and Game Commission should recommend approval, full payment of $3,930.73 would be due.