26. 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 petitions for regulation change received at the Jun 2017 meeting.

(B) Update on pending regulation petitions referred to staff or DFW for review.

Summary of Previous/Future Actions

(A)

- Receipt of new petitions — Jun 21-22, 2017; Smith River
- **Today's action on petitions** — **Aug 16, 2017; Sacramento**

(B)

- **Today's update and possible action on referrals** — **Aug 16, 2017; Sacramento**

Background

As of Oct 1, 2015, 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, unless the petition is rejected under 10-day staff review as prescribed in subsection 662(b).

Petitions scheduled for consideration today under 26(A) were received at the Jun 2017 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 forum. Petitions considered under 26(B) were scheduled for action at a previous meeting and were referred by FGC to DFW or FGC staff for further review prior to action.

(A) ***Petitions for regulation change.*** Exhibit A1 summarizes the regulation petitions scheduled for FGC action today and provides staff recommendations for each. Two marine regulation petitions were received in Jun 2017 and scheduled for FGC action at this meeting:

I. *Petition #2017-004 (authorize commercial open access fishing for market squid in northern California)* (Exhibit A2)
II. *Petition #2017-005 (create twenty northern pink shrimp permits)* (Exhibit A3)

(B) ***Pending regulation petitions.*** This item is an opportunity for staff to provide a recommendation on petitions previously referred by FGC to DFW or FGC staff for review. FGC may act on any staff recommendations made today. Two updates on pending petitions referred to FGC staff or DFW are scheduled for action at this meeting:

I. *Petition #2016-018 (allow year-round recreational Chinook salmon fishing in Santa Cruz Harbor):* DFW recommends that FGC deny the request (see petition and DFW memo in exhibits B1 and B2, respectively).

II. *Petition #2016-020 (ban recreational fishing of sharks and rays using bow and arrow and harpoon gear):* DFW recommends that FGC deny the request (see petition and DFW memo in exhibits B3 and B4, respectively).

Significant Public Comments

(A) The California Wetfish Producers Association does not support authorization of open access fishing opportunity for market squid and provides rationale and historical context for the current limited entry permit program (Exhibit A4).

Recommendation

(A) Adopt staff recommendations for regulation petitions to (1) deny, (2) grant, or (3) refer to committee, DFW, or FGC staff for further evaluation or information-gathering. See Exhibit A1 for FGC and DFW staff recommendations for each regulation petition.

(B) Adopt DFW recommendations for regulation petitions #2016-018 and #2016-020, previously referred to DFW for review and recommendation.

Exhibits

A1. FGC table of marine petitions for regulation change received through Jun 22, 2017
A2. Petition #2017-004: Authorize commercial open access for market squid in northern California
A3. Petition #2017-005: Create north pink shrimp permits
A4. Email from California Wetfish Producers Association, dated Jul 30, 2017
B1. Petition #2016-018: Recreational take of Chinook salmon in Santa Cruz Harbor
B2. DFW Memo regarding Petition #2016-018, dated Jul 18, 2017
B3. Petition #2016-020: Ban recreational shark and ray fishing with bow and arrow
B4. DFW memo regarding Petition #2016-020, dated Jul 18, 2017

Motion/Direction

(A-B) Moved by _____ and seconded by _____ that the Commission adopts the staff recommendations for action on the June 2017 petitions for regulation change and pending petitions #2016-018 and #2016-20.

OR

Moved by _____ and seconded by _____ that the Commission adopts the staff recommendations for action on the June 2017 petitions for regulation change and pending petitions #2016-018 and #2016-20, except for item(s) _____ for which the action is _____.

CALIFORNIA FISH AND GAME COMMISSION
DECISION LIST FOR MARINE PETITIONS FOR REGULATION CHANGE RECEIVED THROUGH JUN 22, 2017, FOR FGC ACTION
Revised 07-27-2017

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 petition through a process **Deny:** FGC is *not willing to consider* the petition **Refer:** FGC *needs more information* before deciding whether to grant or deny the petition

Tracking No.	Date Received	Accept or Reject	Name of Petitioner	Subject of Request	Code or Title 14 Section Number		Staff Recommendation	FGC Decision
2017-004	6/6/2017 Revised version 6/8/17	A	Robert Juntz Caito Fishing Inc., North Coast Fisheries Inc., and Ocean Fresh LLC; Dan Yoakum (F/V Casey III); and Bill Forkner (F/V Shirley)	Market squid	53.03, T14	Authorize a commercial open access fishing opportunity for market squid in Northern California (north of Point Arena to CA/OR boarder) under a seasonal quota of 950 tons and daily boat limit of 5 tons	DENY; however, request item be considered during next Fisheries Management Plan review and potential amendment.	RECEIPT: 6/21-22/2017 **ACTION: Scheduled 8/16/2017**
2017-005	6/6/2017	A	Scott Hartzell	Northern pink shrimp permits	120.2, T14	Create 20 new non-transferrable permits with specified fees,annual renewal, modified boundaries, and forfeiture conditions	REFER to MRC; pink shrimp permit capacity topic currently scheduled for Nov 2017 MRC meeting	RECEIPT: 6/21-22/2017 **ACTION: Scheduled 8/16/2017**

State of California – Fish and Game Commission
PETITION TO THE CALIFORNIA FISH AND GAME COMMISSION FOR REGULATION CHANGE
FGC 1 (NEW 10/23/14) Page 1 of 3

2017-004

Tracking Number: ~~(Reference attached document)~~

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: Robert Juntz, Representing: Caito Fisheries Inc, North Coast Fisheries Inc, Ocean Fresh LLC, Noyo Fish Company, Dan Yoakum (F/V Casey III), Bill Forkner (F/V Shirley) and the Fort Bragg Fishing Community.

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: Authority cited: Sections 7078, 7701, 7708, 8026, 8425 and 8429.5 and the Fish and Game Code.

3. **Overview (Required) -** Summarize the proposed changes to regulations: We are requesting changes to existing market squid regulations to allow anybody holding a current CA commercial fishing license, and on a CA commercially registered vessel to be able to harvest 5 tons per day of market squid with a cap of 950 tons total in the waters north of Point Arena to the California Oregon border. The fishing methods would be consistent with existing rules, methods, times IE, Methods seine, lampara, braile etc. This 950 tons if not caught between Apr 1st – Jan 1st would revert back to the limited entry permittees. This 950 tons is less than 1 % of existing quota. We are open to variations of this proposal as to fit controlling agencies and user groups. After implementation we would like to reassess this fishery every 3 – 5 years.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: The biggest problem we are facing is the FMP unknowingly took the biggest and most abundant fishery in California and gave it to 55 fishers without taking into account the future needs and access of Northern California Fishing Communities. The prices of these permits have skyrocketed to over one million dollars, and made it unattainable for the fishermen of Northern California to have access to a resource that is right out in front of the harbor. Another problem is the quota is based on central California south, not taking into account the enormous amount of squid we have here. These squid are here year in and

out; they are not here due to El Nino conditions only. The solution is a community based squid fishery with its own quota in the ports of Noyo, Eureka and Crescent City. This quota will give the local fishing-based communities an opportunity to make use of a natural local resource, create jobs, industry and save these ports that are in serious danger of failing.

SECTION II: Optional Information

5. Date of Petition: 6th of June, 2017

6. Category of Proposed Change
- ☐ Sport Fishing
- ☒ Commercial Fishing
- ☐ Hunting
- ☐ Other, please specify: Click here to enter text.

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):149
- ☐ 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 2015-007
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: As Soon As Possible.

10. Supporting documentation: Identify and attach to the petition any information supporting the proposal including data, reports and other documents: Click here to enter text.

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: This proposal would help create jobs and revenue to support the local fishing communities. We are open to current economic taxation on market squid and if this would increase workload on the department an increased tax to accommodate excess workload.

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

Click here to enter text.

SECTION 3: FGC Staff Only

Date received: 6/8/17 ~~Click here to enter text.~~

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: June 9, 2017

Meeting date for FGC consideration: August 16-17, 2017

FGC action:

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

State of California – Fish and Game Commission
PETITION TO THE CALIFORNIA FISH AND GAME COMMISSION FOR REGULATION CHANGE
FGC 1 (NEW 10/23/14) Page 1 of 2

2017-005

Tracking Number: (~~unsure- please enter~~)

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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.

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2017 JUN -6 PM 2:11
CALIFORNIA
FISH AND GAME
COMMISSION

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: Scott R. Hartzell .

2. **Rulemaking Authority (Required)** - Reference to the statutory or constitutional authority of the Commission to take the action requested: **Sections 713, 1050, 8591, 8841, & 8842 Fish & Game Code Ref: Sections 1050, 7852.2, 7858, 8101, 8591,& 8842.**

3. **Overview (Required)** - Summarize the proposed changes to regulations: Create 20 new non-transferable Northern Pink Shrimp permits. To be sold @ $50,000 each & renewed every year or forfeiture. No overall length limit to be associated with the permit. Move the fishery back inside the 3 mile demarcation line with certain exceptions. Require: 10 shrimp deliveries within 5 years or forfeiture

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: Under utilized fishery, needed revenue for the state and commercial fishermen.

SECTION II: Optional Information

5. **Date of Petition: May 29, 2017**.

6. **Category of Proposed Change**
   ☐ Sport Fishing
   x Commercial Fishing
   ☐ Hunting

☐ Other, please specify: Click here to enter text.

7. **The proposal is to:** (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)
x Amend Title 14 Section(s):Section 120.2, Title 14, CCR, H
☐ 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 x 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: as soon as possible.

10. **Supporting documentation:** Identify and attach to the petition any information supporting the proposal including data, reports and other documents: none.

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: The current Pink Shrimp Fishery has evolve: to have minimal impact on the bottom terrain & its non-targeted species. Create economic gains for California's much needed commercial fisheries.

12. **Forms:** If applicable, list any forms to be created, amended or repealed:
none

SECTION 3: FGC Staff Only

Date received: ~~Click here to enter text.~~ June 6, 2017

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

CALIFORNIA WETFISH PRODUCERS ASSOCIATION
PO Box 1951 • Buellton, CA 93427 • Office: (805) 693-5430 • Mobile: (805) 350-3231 • Fax: (805) 686-9312 • www.californiawetfish.org

July 30, 2017

Mr. Eric Sklar, President
Members of the Fish and Game Commission
1416 Ninth Street
Sacramento, CA 95814

RE: Agenda Item 26 ~ Action on petitions for regulation change
I. Petition #2017-004 to authorize commercial access fishing opportunity for market squid in northern California

Dear President Sklar and Commissioners,

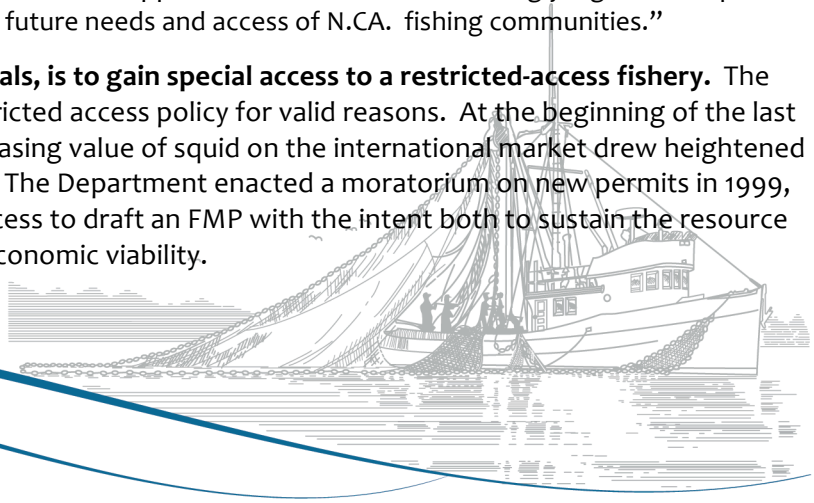
As you're aware, CWPA represents a majority of fishermen and processors who land and process coastal pelagic species in California, including market squid. Unfortunately I am unable to attend the Commission meeting on September 16, so I would greatly appreciate your consideration of the following comments on behalf of the squid / wetfish industry at large, regarding Agenda Item 26, continuing discussion re: commercial access to the squid fishery in northern CA.

This issue has appeared on the Commission agenda periodically for several years in different iterations, but the gist has always been to allow exclusive opportunity for N.CA. fishermen to harvest squid outside the limits of the current restricted access policy. Over these years, CWPA, the wetfish industry and I personally have invested a lot of time, thought and discussion, considering potential alternatives that could be accomplished within the current regulatory framework or with surgical regulatory change that could apply across all fisheries, and without harming the existing wetfish industry, for whom the squid fishery is an essential part – and now virtually the only part – of their livelihood.

Our discussions triggered a flood of questions: What about the restricted access policy itself and the precedent that reversing it would set for all other fisheries? What about the rest of the State: why should northern CA. receive preferential treatment? What socio-economic harm would befall the existing limited entry squid fleet — the fishermen and processors who have invested millions of dollars to develop the fishery because restricted access policy limited overexploitation, and the fishery is now fully utilized, in light of capacity limits set in the Market Squid Fishery Management Plan (FMP).

In reviewing the most recent petition for regulation change, I realized that, despite countless hours of discussion with the proponents, they have not acknowledged nor addressed any of these concerns. Rather, I found misrepresentations in the rationale, for example the statement that the Commission approved an FMP that "unknowingly… gave the squid fishery to 55 fishers without taking into account the future needs and access of N.CA. fishing communities."

The root of this petition, as with the earlier appeals, is to gain special access to a restricted-access fishery. The Commission approved the squid FMP and its restricted access policy for valid reasons. At the beginning of the last decadal squid "boom" in the late 1990s, the increasing value of squid on the international market drew heightened interest from fishermen, many from out of state. The Department enacted a moratorium on new permits in 1999, and initiated a multi-year, multi-million-dollar process to draft an FMP with the intent both to sustain the resource and stabilize the fishery, including its long-term economic viability.



Quoting from the Market Squid FMP:

Sec. 2.2 Restricted Access (Sec. 2-21)

Restricted access programs should: 1) contribute to sustainable fisheries management by providing a means to match the level of effort in a fishery to the health of the fishery resource and by giving fishery participants a greater stake in maintaining sustainability; 2) provide a mechanism for funding fishery management, research, monitoring, and law enforcement activities; 3) provide long term social and economic benefits to the State and fishery participants; and 4) broaden opportunities for the commercial fishing industry to share management responsibility with the Department. More specifically, the Commission's purposes for restricting access or entry to a fishery are described as: 1) promote sustainable fisheries; 2) provide for an orderly fishery; 3) promote conservation among fishery participants; and 4) maintain the long term economic viability of fisheries. Restricted access programs may be instituted in order to carry out one or more of these purposes in a given fishery.

Sec. 2.2.1 Limited Entry / Capacity Goals

Establishing limited entry qualifying criteria is a first step in reducing fleet size from the 184 market squid vessels and 41 light boats currently permitted to achieve the selected capacity goal, provided the current number of vessels is in excess of the selected goal.

Sec. 2.2.2 Initial Issuance of Market Squid Fleet Permits

California has had a practice of giving preference to vessels of fishermen with past participation when issuing restricted access permits. Among fishermen or vessels with past participation in the squid fishery, preference for permits may be based on factors such as years of participation in the fishery or level of participation (landings).

The Commission approved a **capacity goal** of 55 seine permits, including three "experimental" permits in northern CA., along with a capacity goal of 34 light boat permits and 18 brail permits (a new category included as a subset of the light boat category to provide one lighting vessel per seiner, and enable a number of smaller vessels to scoop limited quantities of squid for specialty markets).

But prior to the FMP there were **184 squid vessel and 41 light boat permits** in the fishery. Thus adoption of the FMP eliminated more than half of the then existing seine fleet, as vessels were required to qualify based on a prescribed number landings in the window period or history in the fishery. The total number of vessels that qualified to remain in the fishery exceeded the capacity goal, but the intent was to attain the capacity goal by attrition and permit stacking.

In 2016 the squid fleet numbered 45 transferable brail permits (up from the 14 issued in 2005 due to a one-time light boat to brail transfer authorized in regulation that inadvertently did not cap transfers at the capacity goal), 30 transferable light boat permits (down from the initial 41 due to the transfers) and 68 transferable seine vessel permits (down from the 77 issued in 2005). Although the seine fleet is working toward its capacity goal, the fishery as a whole has not reached it yet. Transferable seine and brail permits now cost $2,764.50 per year, among the most expensive commercial fishing permits in California, and fishermen must pay this fee annually to remain in the fishery, regardless of whether or not they go fishing. But the 'good' news is 113 permits are eligible for transfer, should someone wish to enter the squid fishery under the existing regulatory framework.

I recall the Commission's initial intent when approving the "experimental" permit class in 2004 was to "develop a fishery in an area previously unfished", but regulations established a time limit for those permits. Why were the three "experimental" squid permits issued at the beginning of the market squid FMP not used? The experimental permits acquired in 2005 were not renewed for a reason:
For example, an article in the Eureka Times Standard, "*Another 'Freakish' Squid Fishing Boom Unlikely*" (dated 10/22/15), posted a telling sidebar:
Yearly squid landings in the Eureka area since 2000:
2014: 4.8 million pounds*
2008: 87 pounds
2006: 300 pounds
2004: 95 pounds
2001: 255 pounds
2000: 1,645 pounds
Source: California Department of Fish and Wildlife

*****Please understand that the 4.8 million pounds landed in 2014 were landed by squid limited-entry fishery participants who had invested millions of dollars in vessels and infrastructure, including mobile pumps, to maximize the harvest and value of the squid resource during a decadal squid "boom". This value was lauded by local businesses in ports like Eureka and Fort Bragg that benefited from the upsurge in economic activity. The current squid limited-entry fleet is mobile and capable of harvesting squid wherever they appear, in northern as well as southern California. However, the current lack of ice and cold storage facilities in northern CA have hampered local processing, and trucking will be required unless or until adequate infrastructure is built.

Everyone can support the goal of achieving sustainable harbor communities. **But sustainability is an issue for all of California's harbors, not just those in northern CA.**

Many harbors are suffering. California's wetfish fleet has little else to harvest besides squid now. The sardine fishery is closed; mackerel, although present, are not often concentrated into fishable schools in waters where the fleet operates; anchovy markets are limited and there are severe restrictions on tuna fishing.

Market squid is now the only economic driver in a historic industry that, until recent years, has contributed as much as 80 percent of California's statewide fishery landings, representing 40 percent of total dockside value. We all feel the pain voiced by the proponents of this petition. We've participated in and paid close attention to the sustainable harbor community workshops that the Commission has sponsored, and we've encouraged the proponents to pursue the model advanced by the City of Monterey, which could include creating a co-op or foundation and purchasing some squid permits, along with permits for other fisheries.

Excerpting from CWPA's earlier discussion document submitted to the Commission:

Potential Long-Term Solutions to achieve Sustainable Harbor Community Goals

- *Follow the precedent set by Monterey and Morro Bay – i.e. develop a Fishing Community Sustainability Plan, identify infrastructure needs and how to secure funding and political support for improvements and focus on securing landings from a diversity of fisheries, which translates to a diversity of gear types operating on a diversity of habitats and relying on a diversity of markets.*

We've noted that these themes are repeated in the summary from the most recent sustainable community workshop in Smith River.

It is important to point out that Northern CA ports historically have relied on groundfish, Dungeness crab, salmon and Pacific Ocean "pink" shrimp. Fort Bragg also has had a viable sea urchin fishery until recent anomalous ocean conditions precipitated an explosion of purple urchins and loss of kelp. The abundance of squid in northern CA is transient, and certainly **squid by itself cannot "save" fishing communities in northern CA.**

After lengthy, serious discussion, a consensus of the wetfish industry continues to express grave concern over the petition now asking for "open access" permits in the squid fishery:

- **Squid fishermen and processors fear the harm caused by reversing restricted access policy to upset the economic sustainability of the existing limited-entry squid fishery and California's wetfish industry**.
- **They also point to the precedent set by issuing new permits to individuals who had not qualified for permits nor invested substantially to participate in the fishery**.

Employing similar logic, why not give squid fishermen Dungeness crab, salmon, spiny lobster or spot prawn permits during times of hardship? (A spot prawn permit recently sold for $1.1 million.) California's wetfish fleet also needs help!

Market squid supports many fishing communities in California. Issuing new "open access" fishery permits in an existing limited-entry fishery would set the precedent for similar consideration in other fisheries and other areas**, would jeopardize the value of existing limited-entry permits, would increase capacity in an already fully utilized fishery and would not be equitable to fishermen who worked hard and risked millions of dollars themselves to secure a place in the fishery initially.**

- **An important purpose of the restricted access program was to provide economic stability. Adding more permits would destabilize the existing limited entry squid fleet and wetfish industry.**

I have engaged in many informal discussions with DFW fishery managers and Commission staff about this issue. On behalf of CWPA and the wetfish industry at large, I agree with recommendations of Marine Region Manager Craig Shuman, who suggested that before acting on any fishery-specific request for regulation change involving a restricted-access fishery, the Commission should consider its overarching restricted access policy and how that is applied across all fisheries. As noted above, given the dynamic, transient behavior of market squid, the squid fishery by itself is not going to save northern CA fishing communities. However, the squid fishery is now the lifeline for California's historic wetfish industry.

CWPA supports the current management framework of the squid FMP, including the goals of the restricted access policy – in particular: *4) broaden opportunities for the commercial fishing industry to share management responsibility with the Department.*

CWPA is pleased to serve as a partner of the Department of Fish and Wildlife in research and management. CWPA has assisted the Department in tracking squid fishery landings since 2013, after the fishery closed early during the "boom" in 2012, with about 11,000 tons remaining in the max cap, which caused a $20 million impact to the industry. We successfully coordinated voluntary participation with all major markets who emailed fish tickets daily to the Department, and fishermen voluntarily restricted fishing days after landings approached about 100,000 tons, stopping for a week to enable the Department to confirm the landings count, then proceeding one trip per day, two days per week, until landings approached the max cap. Fishermen stopped fishing voluntarily, before landings reached 118,000 tons. We are continuing this cooperative management agreement even though fishery landings have been sharply reduced during the 2015 El Niño and its aftermath.

We have also conducted a squid research program for many years, in cooperation with the Department and the Southwest Fisheries Science Center. I'm happy to announce that a paper reporting our supervising squid scientist's research findings 2011-2016 was recently published in the journal *Marine Ecology*. I have attached highlights from that paper following our comment letter.

I have also included an infographic illustrating the importance of wetfish / squid to numerous harbor communities, as well as to California's fishing economy.

We look forward to further cooperation in both fishery research and management, and will be happy to discuss market squid management policy at the appropriate time in the future.

In the meantime, thank you very much for considering our comments.

Best regards,

Diane Pleschner-Steele

Diane Pleschner-Steele
Executive Director

HIGHLIGHTS FROM VAN NOORD, ET AL
Published 20 Jun 2017

Van Noord JE, Dorval E. Oceanographic influences on the distribution and relative abundance of market squid paralarvae (*Doryteuthis opalescens*) off the Southern and Central California coast.
Mar Ecol. 2017;38:e12433. https://doi.org/10.1111/maec.12433

Summary

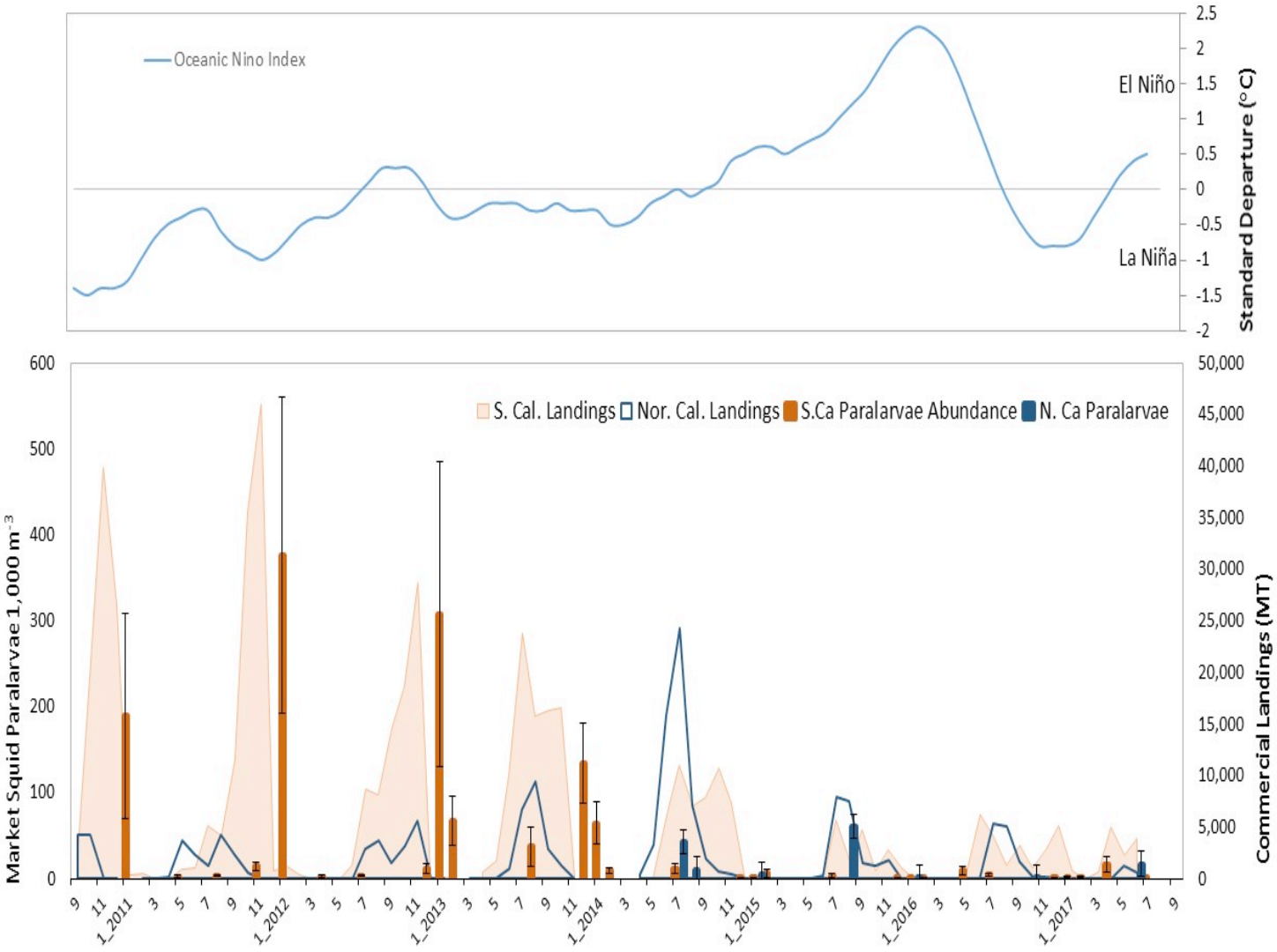
This study represents the most comprehensive, on-going effort to directly assess the relative abundance of market squid paralarvae in nearshore waters and the conditions that influence the variability in the stock, density and distribution. Warm temperatures pose ecological and physiological limitations on squid through feeding constraints and metabolic stress that alter the timing and location of spawning. We found that the densities and distribution of market squid paralarvae show a strong relationship to local sea surface temperatures and ocean productivity, where colder temperatures and moderate zooplankton displacement volumes promote greater paralarval densities, while warmer temperatures cause the population to spawn earlier, shift north, and contract. These findings indicate that squid abundance, distribution, and timing of spawning are largely driven by environmental forcing, while the effect from the fishing pressure is likely much less.

ENSO cycles control the abundance, distribution and maturity rate of market squid

- The abundance, distribution, and maturity rate (which controls the timing of spawning and recruitment to fishing grounds) of market squid are strongly influenced by warm and cool cycles of the El Niño Southern Oscillation (ENSO).

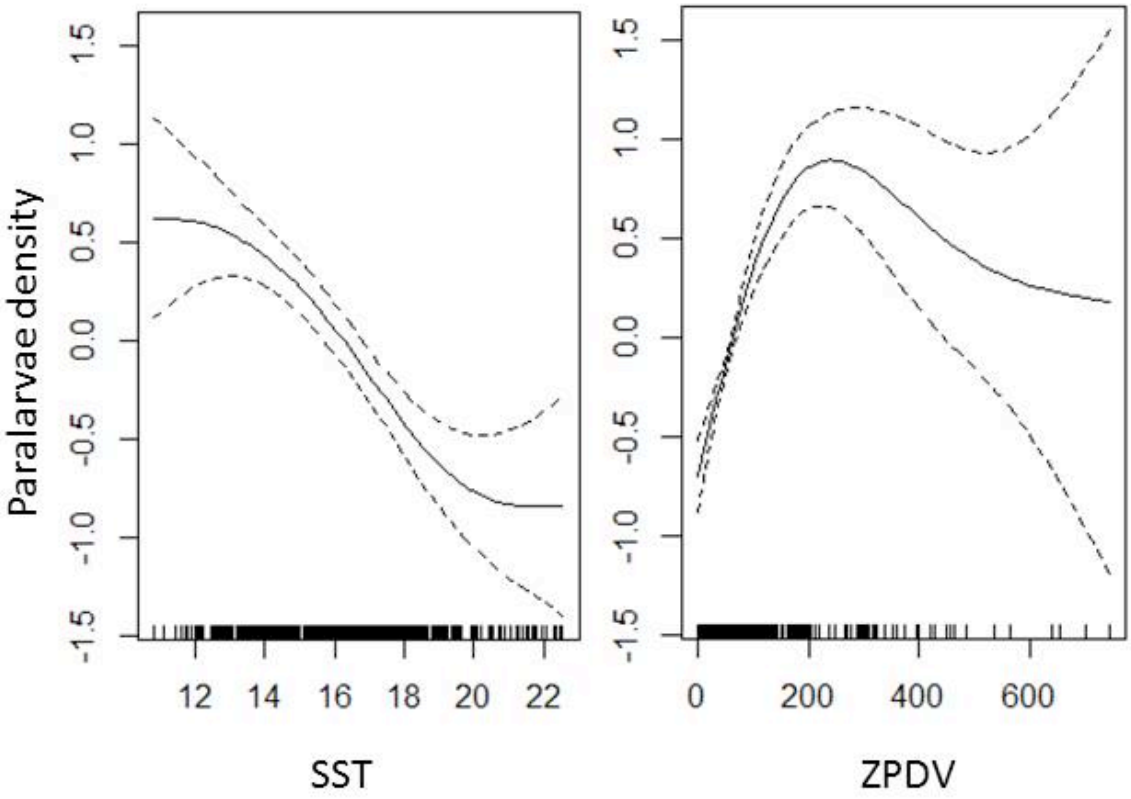
- During La Niña events the ocean temperature is cooler and the ecosystem is more productive than normal. During El Niño events the opposite is true, the ocean temperature is warmer and the ecosystem is unproductive compared to the long-term average.

- Warm oceanic conditions pose ecological and physiological challenges to market squid at multiple life-history stages.
    - Warm waters yield fewer zooplankton, resulting in reduced prey for squid
    - Warmer waters result in greater egg failure and less paralarvae hatching
    - Paralarvae are born with reduced egg-yolk (an initial and critical food source)
    - Metabolic rate is increased with greater ocean temperatures, requiring more food for sustaining growth
    - Maturation rate increases, which alters timing of spawning and can effect synchronicity with seasonal upwelling events.

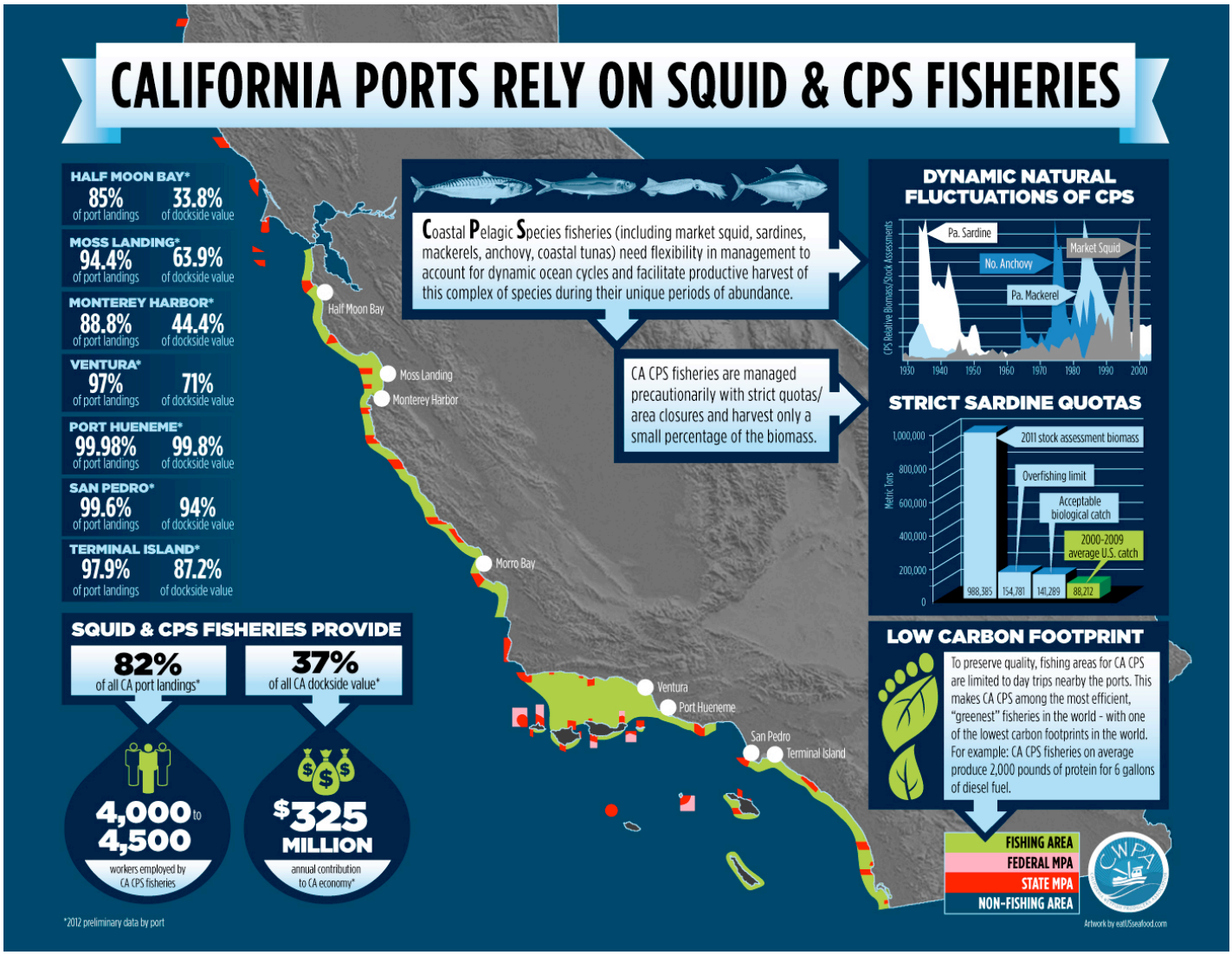


- The above time series shows the effect of an ENSO cycle (top panel showing the Oceanic Niño Index) on squid abundance, distribution, and timing of spawning (bottom panel):
    - Ocean conditions are cool and productive (La Niña) from late 2010 – 2013, commercial landings (shaded areas) and paralarval abundance (bars) are high, particularly in southern California (orange colors).
    - Ocean temperatures gradually rise in late 2013 (neutral conditions) and cause a temporal shift in spawning, squid mature early and recruit to the Southern California spawning beds during late spring and summer, instead of autumn and winter.
    - Continued warming causes a distributional shift, squid can be found recruiting further north (blue lines and bars) to Monterey Bay spawning beds.
    - As a near-record El Niño peaks in 2016, both commercial landings and paralarval abundance decrease to very low levels in the traditional spawning locations.

Oceanographic variables explain variability in paralarval density



- Sea surface temperature (SST) and zooplankton displacement volume (ZPDV – a measure of zooplankton abundance and availability as prey) are strongly correlated with paralarval density.
- The above figure shows the effect of SST and ZPDV on paralarval density. The solid lines indicate the estimated paralarval density at a measured SST or ZPDV measurement. A value of 0 on the vertical axis indicates no effect on paralarval density. A positive value indicates greater paralarvae, and a negative value indicates fewer. The dotted line is the 95% confidence interval.
- The left panel shows greater paralarval densities associated with colder temperatures, and an adverse effect of warm temperatures (>17 C°) on paralarval density.
- The right panel indicates zooplankton abundance and paralarval densities are positively correlated, when zooplankton abundance is low, paralarvae abundance is also low. As zooplankton abundance increases, paralarval densities increase as well. This trend continues until the ocean environment is saturated with enough zooplankton and there is no effect after ~200 ml displacement.
- Sea surface temperature, zooplankton abundance, chlorophyll concentration, and geographic and temporal variables combined to explain 41% of the variability associated with paralarval densities (Van Noord & Dorval 2017).


CALIFORNIA PORTS RELY ON SQUID & CPS FISHERIES
HALF MOON BAY*
85% of port landings
33.8% of dockside value
MOSS LANDING*
94.4% of port landings
63.9% of dockside value
MONTEREY HARBOR*
88.8% of port landings
44.4% of dockside value
VENTURA*
97% of port landings
71% of dockside value
PORT HUENEME*
99.98% of port landings
99.8% of dockside value
SAN PEDRO*
99.6% of port landings
94% of dockside value
TERMINAL ISLAND*
97.9% of port landings
87.2% of dockside value
Half Moon Bay
Moss Landing
Monterey Harbor
Morro Bay
Ventura
Port Hueneme
San Pedro
Terminal Island
Coastal Pelagic Species fisheries (including market squid, sardines, mackerels, anchovy, coastal tunas) need flexibility in management to account for dynamic ocean cycles and facilitate productive harvest of this complex of species during their unique periods of abundance.
CA CPS fisheries are managed precautionarily with strict quotas/ area closures and harvest only a small percentage of the biomass.
DYNAMIC NATURAL FLUCTUATIONS OF CPS
CPS Relative Biomass/Stock Assessments
Pa. Sardine
No. Anchovy
Pa. Mackerel
Market Squid
1930 1940 1950 1960 1970 1980 1990 2000
STRICT SARDINE QUOTAS
Metric Tons
1,000,000
800,000
600,000
400,000
200,000
0
2011 stock assessment biomass
Overfishing limit
Acceptable biological catch
2000-2009 average U.S. catch
988,385
154,781
141,289
88,212
SQUID & CPS FISHERIES PROVIDE
82% of all CA port landings*
37% of all CA dockside value*
4,000 to 4,500 workers employed by CA CPS fisheries
$325 MILLION annual contribution to CA economy*
LOW CARBON FOOTPRINT
To preserve quality, fishing areas for CA CPS are limited to day trips nearby the ports. This makes CA CPS among the most efficient, "greenest" fisheries in the world - with one of the lowest carbon footprints in the world. For example: CA CPS fisheries on average produce 2,000 pounds of protein for 6 gallons of diesel fuel.
FISHING AREA
FEDERAL MPA
STATE MPA
NON-FISHING AREA
CWPA
*2012 preliminary data by port
Artwork by eatUSseafood.com

Tracking Number: 2016-018

A request to amend my original petition that I submitted 8/17/2016.

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

- **Person or organization requesting the change (Required)**
  Name of primary contact person: Neli Cardoso
  Address:
  Telephone number:
  Email address:

- **Rulemaking Authority (Required)** - Reference to the statutory or constitutional authority of the Commission to take the action requested: **Authority 205 and Authority 207**

- **Overview (Required)** - Summarize the proposed changes to regulations:
- Allow Salmon fishing all year round in the Santa Cruz Harbor. The Harbor would include all waters starting at the Jetty Mouth and going to the North end of the Harbor. The Santa Cruz Harbor Commisssioners have the authority to set places and times and restrictions as to when individuals could fish for Salmon. In the past the Commissioners have allowed Salmon fishing on the West Jetty, on docked boats and at the North end of the Harbor. The reason I am asking for a year round authorization to catch Salmon in the Harbor is one can never be sure exactly when the Salmon will show up or how long it will take the sea lions to eat all the

Salmon.

- **Rationale (Required) -** Describe the problem and the reason for the proposed change:
- The problem is Salmon from the "Salmon Project" come back to the Harbor to spawn. This brings into the Santa Cruz Harbor sea lions who feed on the trapped Salmon. The sea lions cause damage to the docks and potential injury to individuals using the docks.
- The reason for proposed change are:

  1. If fishermen and fisherwoman are allowed to catch salmon all year in the Harbor then there will be less salmon for the sea lions to eat. Less Salmon will decrease the sea lions in Harbor which will decrease the problems of sea lions in the Santa Cruz Harbor.
  2. The only individuals catching Salmon in the Harbor in 2016, were sea lions. Fishermen and fisherwoman were deprived of the opportunity to catch Salmon in the Santa Cruz Harbor because of the Salmon season regulations. This was a waste of the Salmon resource in the Harbor.
  3. Allowing fishing for Salmon in the Harbor not only is a good use of the Salmon but it allows lower income and young people an opportunity to catch a big Salmon at a pretty reasonable cost. It costs a lot of money to go out into the Bay, most of the time I go to Soquel Hole where I have caught most of my 28 Salmon in 2016. I have a small 17 foot boat that loves to catch fish. The slip rent is over $2,000,/ year and there are a lot more costs for my boat. To go out Salmon fishing on a charter is also expensive. But fishing on the Jetty or at the North end of the Harbor is not expensive. In the past I've watched adults catch big Salmon on the Jetty. I have also seen young children catch big salmon at the North end of the Harbor. It was something very wonderful to see. I screamed and yelled my approval along with everybody else when a young fishermen or fisherwoman landed a big salmon. Think about your first big fish you caught. Having children fish for big salmon at the end of the Santa Cruz Harbor is what fishing is all about. The Salmon are there and the cost for children to fish for Salmon is very little. We need you to give the okay. I promise you that you will make a lot of kids very happy. The real questiion is it better for the children and adults to catch the Salmon or is it better for the sea lions to catch the Salmon?

SECTION II: Optional Information

- **Date of Petition: Original Date 8/17/2016 Today's 2/3/2017**
- **Category of Proposed Change**

Sport Fishing

- **The proposal is to:** (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)
  Amend Title 14 ,Division1.,Subdivision1.,Chapter 4.,Article 1

- **Effective date**: Desired Effective Date
- July 1, 2017

- Economic of Fiscal Impact:
- The impact on the Santa Cruz Harbor Docks has already happened. New docks that a few years ago were installed have been damaged by hauled out sea lions who feast on Salmon in the Harbor. I was talking to a fisherman who fished for crabs and kept live crabs in a barrel by his boat. As he was retreving crabs a sea lion came out of the water and he came very close to being bitten by the sea lion. The Santa Cruz Harbor has an added expense of keeping sea lions off of docks. It is just a matter of time before some body is seriously injured due to sea lions hauled out on docks.
- The positive impact of fishermen or fishermowan catching a big Salmon is two fold. First there is the food source at a reasonable price. As you all, I am sure have experienced, what a treat it is to eat fresh salmon. For me, I am spoiled. I've eaten so much fresh salmon that frozen salmon has lost it's appeal it once had before I got my fishing boat. Salmon is a healthy food for all individuals including low income individuals. The second is the joy I hope you all have experienced by catching a big Salmon. Catching a big Salmon even a medium size salmon makes a person very happy. Some would say the screams and yells you hear from those in other fishing boats and your boat which comes from catching a Salmon are some of the most joyous screams and yells that there are. People spend a lot off money to catch a Salmon. People travel to Alaska to catch big Salmon. You have the power to make a lot of fishermen and fisherwomen and children happy by allowing Salmon fishing in the Santa Cruz Harbor year round. Please do so.
- I submitted my first request last August for the 2016, season which is past. Nobody legally caught Salmon in the Santa Cruz Harbor in the 2016, except the sea lions. So please do what it takes to make fishing for Salmon legal in the Harbor for the coming season and for future seasons. Thank you.

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

SECTION 3: FGC Staff Only

Date received:

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

State of California
Department of Fish and Wildlife

Memorandum

Date: July 18, 2017

To: Valerie Termini
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Petition #2016-018: Allow Year-Round Recreational Chinook Salmon Fishing in Santa Cruz Harbor**

The Department of Fish and Wildlife (Department) has reviewed the above-referenced petition and recommends the Fish and Game Commission decline to act on the request.

The circumstances prompting this petition are unlikely to be repeated, as the Department expects that returning adult Chinook Salmon will no longer congregate in Santa Cruz Harbor due to recent changes in practice regarding the release of juveniles. Additionally, should the Fish and Game Commission (Commission) authorize a harbor fishery during times when salmon fishing is closed in federal ocean waters, it would require new and extensive environmental analyses and robust fishery monitoring, which the Department would need to design, fund, and implement. Finally, the Santa Cruz Port District (SCPD) currently prohibits this fishery in the harbor, which should be a factor in considering the need and outcome of any state regulatory action to allow fishing in this area.

Background

In August 2016, and again in February 2017, a petition was filed with the Commission requesting that recreational Chinook Salmon fishing be allowed year-round within Santa Cruz Harbor. The requests are in response to a human-induced influx of adult Chinook Salmon returning to the harbor due to juvenile release strategies that have since changed. In past years, net pens located within Santa Cruz Harbor were used to acclimate juvenile Chinook Salmon in the harbor's brackish waters for an extended period of time before the fish were released from the pens.

The petition cites damage caused to docks and a potential increased risk of injury to people utilizing the harbor due to higher than typical numbers of sea lions entering the harbor to feed on these salmon. The petition further claims that potential property

damage and human injury might be reduced if people were allowed to harvest the salmon. It also states that allowing a recreational fishery inside Santa Cruz Harbor would provide an opportunity for young people and lower-income individuals to catch and eat fresh salmon who may not otherwise have access to a boat. Petitioners further request a *year-round* fishery due to uncertainty in when the salmon will enter the harbor in any given year.

Changes in Release Strategy

The Department recognized the issues caused by net pen-released salmon imprinting on water within Santa Cruz Harbor and temporarily discontinued the net pen acclimation program in 2015 and 2016. Net pen releases resumed in 2017, but changes have been made to methods in order to reduce the likelihood that salmon would return to Santa Cruz Harbor as adults. Rather than holding the juveniles in the harbor for days or weeks as had been done in the past, they were placed in the net pens and towed about a quarter mile outside the harbor entrance and released within a few hours.

This release strategy should greatly reduce any imprinting on Santa Cruz Harbor, minimizing the likelihood that these fish will return to the harbor as adults. Since the release practices that generated the influx of adult salmon into Santa Cruz Harbor have now been discontinued, the Chinook Salmon fishery that this request is predicated upon is unlikely to exist in the future. After 2018, there is no expectation that adult Chinook Salmon will return to Santa Cruz Harbor.

Environmental Analysis and Fishery Monitoring

Ocean salmon fisheries are federally managed and regulated under the Magnuson-Stevens Fishery Conservation and Management Act, consistent with the Endangered Species Act (ESA) and pursuant to the National Environmental Policy Act (NEPA). The Department participates in the federal season-setting process, and contributes to the annual environmental analysis and assessments needed to establish fishing seasons and regulations.

Should there be a desire to pursue this fishery inside the state waters of Santa Cruz Harbor during times when salmon fishing is closed in federal ocean waters, the Department would first need to prepare a California Environmental Quality Act (CEQA) analysis to evaluate any environmental impacts of the fishery. Additionally, if the fishery were to proceed as requested in the petition, there would need to be a robust, uniquely tailored monitoring program in order to ensure that this state-waters fishery is operating consistently with the NEPA analysis showing acceptable impacts on ESA-listed stocks and other salmon stocks of concern. The Department does not have discretionary resources to prepare such a CEQA analysis, or to design and implement additional salmon fishery monitoring programs for such a state-waters fishery.

Santa Cruz Port District (SCPD)

Currently, Article II, Section 213 (g) of *Santa Cruz Harbor Ordinances*, generally prohibits fishing inside the harbor except for fishing directly from the jetties, which is allowed at all times. However, between 2012-2014, the SCPD made an exception to allow shore and boat-based access to the net pen-released salmon returning to the harbor during times when Chinook Salmon fishing was open in federal and state ocean waters. However, due to concerns over property damage, trespassing onto private boats and docks, theft, navigational concerns for boats and stand-up paddle boarders, public safety, and increased enforcement costs, the SCPD discontinued allowing salmon fishing inside the harbor in August 2014.

Since then, the SCPD has given no indication that they plan to reconsider allowing fishing activity in the harbor. Furthermore, the Department understands from planning discussions to resume the net pen program in 2017 between the Department, the Monterey Bay Trout and Salmon Project, and the SCPD that a fishery in the harbor would be an unintended outcome of the project. Thus, should the FGC approve this request to allow a Chinook Salmon fishery inside Santa Cruz Harbor, the SCPD would still be expected to maintain its general prohibition on fishing in the harbor except from the jetties.

If you have any questions or need additional information about the Department's recommendation to deny this petition, please contact Dr. Craig Shuman, Marine Regional Manager by telephone at (805) 568-0216, or via email at Craig.Shuman@wildlife.ca.gov.

ec: Stafford Lehr, Deputy Director
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State of California – Fish and Game Commission
PETITION TO THE CALIFORNIA FISH AND GAME COMMISSION FOR REGULATION CHANGE
FGC 1 (NEW 10/23/14) Page 1 of 3

Tracking Number: (2016-020 Revised ~~Click here to enter text.~~)

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).

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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: Michael L. Domeier, Ph.D.
   Address:
   Telephone number:
   Email address:

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: Title 14; Division 1; Subdivision 1; Chapter 4; Article 1; Sections 200, 202, 205, 219 and 220, Fish and Game Code

3. **Overview (Required) -** Summarize the proposed changes to regulations: Disallow bow and arrow and harpoon as legal gear types for the recreational take of sharks and rays

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change: It is important to manage fish and game resources wisely and ethically. Laws are put in place to protect the wild populations of fish and game while allowing for a sustainable level of harvest. Some laws are put in place for ethical reasons, to provide the wild fish and game a minimal level of "fairness." For example, hunters are not allowed to attract and kill game by baiting. Deer, bear, and waterfowl are all good examples of game that could be easily and unethically killed if hunters were allowed to attract them with bait. In some cases methods of hunting or fishing develop that are outside the scope of what resource managers considered when implementing the laws that regulate the sport. Bowhunting for sharks is a method of killing sharks that has recently gained some popularity, and one that has fallen into the grey area between fishing and hunting, where current laws do not adequately protect the sharks. Bowhunting for sharks consists of attracting sharks to the hunting boat and then shooting them in the head with an arrow at very close range. This practice should be banned for many reasons. First, it is a form of hunting, not fishing, and baiting is considered unethical and illegal in the realm of hunting. Second, sharks are slow growing species with very low reproductive rates. Shark bowhunting targets the very largest sharks and therefore is killing off the mature, breeding portion of the population. If this method of killing sharks were to become popular it would be an unsustainable method of harvesting sharks. And

finally, large sharks often have body burdens of heavy metals and toxins that are far above what has been deemed to be safe for human consumption, making them inedible. If the sharks can't be eaten they should not be killed. Furthermore, catch-and-release is not an option when this method of take is used. The number of people targeting sharks with bow and arrow are currently few. Banning the practice now, before it becomes more popular, would impact a very small percentage of the hunting and fishing community.

SECTION II: Optional Information

5. Date of Petition: 25 August 2016

6. Category of Proposed Change

☒ Sport Fishing
☐ Commercial Fishing
☐ Hunting
☐ Other, please specify: Click here to enter text.

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):28.95
☐ 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: 1 January 2017

10. Supporting documentation: Identify and attach to the petition any information supporting the proposal including data, reports and other documents: I have attached research papers that document the very high body burdens of toxins in sharks and rays.

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: The number of participants in the recreational bow and arrow and harpoon fisheries is very small, so this proposed rule change would have very little economic impact

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

Click here to enter text.

SECTION 3: FGC Staff Only

Date received: Click here to enter text.

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: 10/10/2016

Meeting date for FGC consideration: December 7-8, 2016

FGC action:

- ☐ Denied by FGC
- ☐ Denied - same as petition _____

Tracking Number

- ☐ Granted for consideration of regulation change

Quantification of Maternal Offloading of Organic Contaminants in Elasmobranchs Using the Histotrophic Round Stingray (Urobatis halleri) as a Model

Article in Environmental Science & Technology · September 2013

DOI: 10.1021/es402347d · Source: PubMed

2 authors:

Kady Lyons
The University of Calgary
11 PUBLICATIONS **56** CITATIONS

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Christopher G. Lowe
California State University, Long Beach
125 PUBLICATIONS **3,686** CITATIONS

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Environmental Science & Technology

Article

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Quantification of Maternal Offloading of Organic Contaminants in Elasmobranchs Using the Histotrophic Round Stingray (*Urobatis halleri*) as a Model

Kady Lyons* and Christopher G. Lowe

California State University, Long Beach 1250 Bellflower Boulevard, Long Beach, California 90840, United States

Supporting Information

ABSTRACT: Maternal offloading is one route by which young animals may accumulate persistent organic pollutants, such as dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyls (PCBs), but has not been well documented in elasmobranchs despite their propensity to accumulate high concentrations of contaminants. Using the round stingray (*Urobatis halleri*) as a coastal elasmobranch model, we examined maternal offloading processes at two stages in the stingray's entire reproductive cycle. Post-ovulated and near-term pregnant female stingrays were sampled from southern California, and organic contaminants were measured in the ova and embryonic tissues and compared to concentrations measured in corresponding female livers to determine route and extent of transfer. Total organic contaminant loads measured in ovulated eggs were about two times lower than loads measured in embryos ($p < 0.001$) indicating mothers have the ability to transfer contaminants throughout pregnancy. Contaminant loads measured in pups showed a positive relationship with mother's contaminant concentrations ($p < 0.001$); however, mothers offloaded relatively low percentages ($1.5 \pm 1.7\%$) of their total contaminant load using contaminants measured in the liver as a proxy. However, histotrophy is only one form of supplemental provisioning utilized by elasmobranchs and variation in reproductive modes likely influences the extent to which female elasmobranchs may maternally offload contaminants.

INTRODUCTION

Polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT) and its metabolic and environmental breakdown products (DDE and DDD) are particularly problematic contaminants because they are lipophilic, resistant to biodegradation, and biomagnify in the fatty tissues of upper trophic level predators.[1] Besides acquiring contaminants from dietary exposure,[2] some species show differences in contaminant concentrations between age and sex classes, indicating that contaminant accumulation can also be influenced by reproduction. Females, unlike males, have the ability to offload contaminants to their offspring, since they provide a direct energetic contribution to nourish developing young.[3] Although mammalian females have been documented to offload contaminants by two pathways, placental transfer during gestation and lactation,[4,5] a majority of contaminants are transferred to young via lactation. During lactation, organochlorines passively follow lipids that are mobilized from blubber to produce lipid-rich milk, which is subsequently consumed by nursing young.[6,7] Since females transfer a substantial portion of their lipid reserves during lactation, organochlorines are transferred to offspring at a greater rate than during gestation.[4]

Elasmobranchs are another group of animals that invest substantial resources into producing well-developed, precocial young and have the potential to offload contaminants to their young as well.[8] Elasmobranchs have an equivalent energy storage organ to blubber (i.e., large lipid-rich livers) where energy is derived to provision young and is the major site where contaminants can accumulate to high concentrations.[9,10] During egg yolk formation, females transfer hepatic lipids to maturing oocytes via a lipoglycophoshoprotein called vitellogenin.[11] Accumulated contaminants are expected to passively follow hepatic lipids as they are mobilized and redistributed in a process similar to milk formation in marine mammals. In addition to large yolk-filled eggs, many viviparous elasmobranchs provide additional nutrition to embryos in the form of yolksac-placental conveyance, oophagy (ovulation of additional unfertilized ova consumed by embryos *in utero*), uterine secretions (histotroph), and/or intrauterine cannibalism.[8] These supplemental provisioning strategies may represent alternative pathways by which contaminants can be transferred to offspring throughout gestation and influence the extent of maternal offloading across reproductive modes in elasmobranchs.

Due to their high trophic positioning, many marine mammals bioaccumulate considerable contaminant loads. Since they serve as a comparable model for humans most research on maternal transfer of contaminants to offspring has focused on marine mammals. Until recently, studies on maternal offloading

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processes in elasmobranchs have been greatly lacking.[12] The low reproductive output of many elasmobranchs and difficulty in obtaining samples have limited the number of in-depth studies examining maternal offloading process using mother-pup pairs.

The round stingray (*Urobatis halleri*) is an abundant species that forages in close proximity to heavily contaminated sediments in southern California[13] and may represent a suitable model for investigating maternal offloading processes in detail. Round stingrays have one of the shortest gestational periods (approximately 3–4 months) of any elasmobranchs. Since embryos deplete their yolk sacs after the first month of development, mothers provide embryos with supplemental nutrition in the form of histotroph, which nourishes developing young for several months until parturition.[14] Therefore, females have the ability to transfer contaminants to offspring via two routes: ovulated eggs and histotroph. Using the round stingray as an elasmobranch model for species with both a lecithotrophic and histotrophic gestational phase, the objectives of our study were to (1) identify pathways of contaminant transfer from mothers to offspring; (2) determine how factors such as maternal age, contaminant concentration, and fecundity influence the amount females offload; and (3) quantify and compare the proportions of three organic contaminant groups (PCBs, chlordanes, DDTs) transferred from mothers to embryos. Examining maternal offloading processes in detail in a species such as the round stingray may allow us to gain insights and make inferences about similar processes occurring in other, more difficult to study elasmobranchs.

EXPERIMENTAL SECTION

Sample Collection. Stingrays were collected in the summer and fall of 2010 and 2011 corresponding to the events of the stingray's reproductive cycle[14,15] at Seal Beach, Colorado Lagoon, and the Seal Beach National Wildlife Refuge, California (Figure S1). Preovulatory (n = 18) and ovulated females (n = 17) were collected near the size of maturity (15.7–17.6 and 14–17.7 cm disk width [DW], respectively). Pregnant females were also collected based on disk width to obtain a wide age range of mothers (16.0–33.0 cm DW, n = 69). Pregnant females were visually selected based on the degree of abdominal distension,[16] and mid- to late-pregnancy females were sampled.

Animals were collected using a large (26 m long × 3 m tall and a 2 m cod end, mesh size 5 and 1.5 cm) or a small (15.2 m long × 1.8 m tall by 0.32 cm mesh) beach seine net. Upon capture, stingrays were sexed, measured (DW, nearest 0.1 cm), and gestation stage was visually assessed for pregnant females. Stingrays were transported back to California State University, Long Beach, (CSULB) where dissections took place. Stingrays were euthanized by immersion in a seawater ice slurry for 30 min followed by spinal pithing, in accordance with approved CSULB IACUC Protocol # 273. Once rays were euthanized, total body and liver weight were obtained and a piece of the left liver lobe was sampled. Preovulatory ova (herein "ova", no. females n = 18) and ovulated eggs (herein "eggs", no. females n = 17) were dissected from the ovary or uterine horns and weighed to the nearest 0.01 g. Embryos were dissected from pregnant females and sex, disk width, and total body, digestive tract (stomach, spiral valve, spleen, and pancreas), and liver weights (0.01 g) were obtained. Embryos were analyzed as litters by pooling and homogenizing the digestive tract and liver from littermates (no. litters = 69); a pilot study previously demonstrated negligible amounts of contaminants in non-visceral tissues (Figure S2). Therefore, all subsequent results for contaminants measured in embryos herein refer to those derived from embryonic visceral tissues (i.e., liver and digestive tract). However, embryos near parturition size from one litter were analyzed as whole individuals to test our assumption that contaminants are distributed equally among littermates. All tissues used for organic contaminant (OC) analysis were subsequently wrapped in foil and stored at −20 °C until chemical analyses could take place.

Chemical Analyses. Tissue extractions and contaminant quantifications were performed at CSULB's Institute for Integrated Research on Materials, Environment and Society. Each sample extract was analyzed for DDT and its derivatives (n = 6), chlordanes (oxychlordane, gamma-, alpha-, trans-, cis-chlordane), and 54 congeners of PCBs and summed to obtain total DDT ("DDTs"), chlordanes ("CHLs"), and PCBs.

Following previously described methods,[18] homogenized ova and embryonic tissues and subsamples of female livers were extracted for 14–16 h via a Soxhlet apparatus in 100% methylene chloride (DCM). Prior to extraction, all samples were spiked with a known quantity of recovery surrogates (TCMX, PCB 30, 112, and 198) to measure efficiency of preparative and analytical procedures (target recovery of 70–130%). Sodium sulfate was added to embryo samples due to their relatively high water content. After extraction, samples were concentrated by rotovap and lipid content was determined gravimetrically from split aliquots. Extracts were then purified through elution through an Alumina-B/Silica gel with hexane, 30% DCM in n-hexane, and DCM and concentrated. Due to small sample weights, ova extracts were transferred to autosampler vial inserts and concentrated (≤100 μL) to increase detection resolution. All samples were spiked with internal standards (4,4′-dibromobiphenyl and 2,2′,5,5′-tetrabromobiphenyl) and injected onto an Agilent gas chromatograph (GC; 6890N series) equipped with a mass selective detector (MSD; Agilent 5973 inert series). The GC column employed was a ZB-5 (Phenomenex; Torrance, California) fused silica capillary (0.25 mm ID × 60 m) with 0.25 μm film thickness. The temperature profile of the GC oven was programmed from 45 to 125 °C at 20 °C/min, then to 295 °C at 2.5 °C/min and held for 10 min. Injector and transfer line temperatures were set at 285 and 300 °C, respectively. The source and quadrupole temperatures were set at 230 and 150 °C, respectively. Helium was used as the carrier gas at a flow velocity of 40 cm/s. The MSD was operated in the electron ionization (EI) mode and scanned from 45 to 500 amu at a rate of 1.66 scans/s. Concentrations of organic contaminants were quantified using the software in the GCMS system (Agilent Technologies).

Quality Assurance/Quality Control. Quality assurance quality control samples were run in tandem with each batch (n = 12) of study samples to ensure accuracy and precision of data acquired and included one blank, one study sample replicate, two duplicate matrix spikes, and one certified reference material (Lake Michigan Trout tissue 1947, National Institute of Standards and Technology). Matrix spikes were prepared by adding spike surrogates to subsamples used for pesticide and PCB analysis. The QC goal was for 90% of the replicates to yield a relative percent difference (RPD) of <30% with recovery of spiked analytes at 70–130%.

The mean ± SD of recovery surrogates was 120 ± 29%, 111 ± 24%, 125 ± 25%, and 84 ± 23% for TCMX, PCB 30, 112,

and 198, respectively, which demonstrated acceptable efficiency of procedures. Recovery of CRM analytes among batches was 94 ± 8% for PCBs and 90 ± 11% for pesticides and blanks showed no signs of procedure contamination. Mean relative significant differences between replicates of sample duplicates and matrix spikes were relatively low (13 ± 14% and 8 ± 9%). Mean recovery of matrix spikes was 91 ± 6% and 82 ± 10% for PCBs and pesticides. Therefore, QA/QC samples satisfied criteria and data were not corrected for recovery.

Data Analysis. OCs per sample were summed as a whole (herein "summed OCs") and reported as either concentration (wet [ww] or lipid [lw] weight basis) or total load (ng). Total load was calculated by multiplying ww concentration by the total weight of the organ or tissue analyzed. OCs for ova, eggs, and embryos were reported as "standardized total load" (i.e., OCs per number of ova, eggs, or embryos obtained from each female [ng/#]) since tissues were of small enough weight to be analyzed whole. Where percentages were compared, values were arcsin transformed prior to analysis.

Ova and Eggs. Factors that were thought to influence contaminants measured in ova and egg tissues were their weight, females' liver concentration, and female's disk width. Therefore, natural log (LN) transformed values were used in a multiple regression to determine the relationship between these factors and measured contaminant loads in ova and eggs. In addition, the percent of a female's total contaminant load that was transferred to ova or eggs (herein "percent offloaded") was compared by t test. A pilot study comparing organic contaminants measured in stingray liver and extra-hepatic tissues (i.e., whole rays excluding liver, $n = 7$) demonstrated that organic contaminant load ([OC] × total tissue weight) found in nonliver tissue contributed very little (3.3 ± 1.6%) to the total body load (Figure S3). Therefore, contaminants measured in livers were used as a proxy for total contaminant load of the animal. The offloading percentages were calculated by the following formula: (egg or ova load)/(female total liver load + egg/ova load) × 100, assuming the contaminant concentrations were homogeneous throughout her liver. Females were expected to have offloaded more contaminants to eggs (fully developed ova) compared to nearly developed (preovulatory) ova found in the ovary.

Eggs and Embryos. Developing embryos typically deplete their yolk reserves by the end of the first or second month at which time females will secrete histotroph to nourish embryos until parturition. Since females provide their young with supplemental nutrition, they have the opportunity to continually offload contaminants throughout pregnancy. To test this hypothesis, we first compared the LN transformed standardized loads offloaded between eggs ($n = 17$) and a subset of near-term embryos ($n = 10$) using Welch's t tests from females of comparable disk widths (15.7–17.6 and 16–17.8 cm DW, respectively) so that females were of similar ages. To ensure that any differences found between eggs and embryos were not due to differences in female contaminant loads before reproduction, female loads prior to ovulation were back calculated by adding egg or embryo loads to female total loads and comparing LN transformed values through a t test.

In addition to total amount of contaminants offloaded, we were also interested in comparing the types of contaminants that were transferred during different stages of reproduction. The percent of ΣPCBs, ΣDDT, and Σchlordanes measured per sample were compared between eggs and embryonic tissues through a generalized linear model using a beta distribution with a logit linked function in SAS 9.3. PCBs were further subdivided into groups by number of chlorinated congeners (i.e., tri, tetra, penta, hexa, hepta, octa, nona) and the proportions compared between embryos and eggs. PCB 209 (deca congener group) was removed from analysis due to number of samples where PCB 209 was detected. Proportions were calculated by dividing the sum of each chlorinated congener group by the total amount of PCBs measured per sample.

Mothers and Embryos. Female age (i.e., disk width) and contaminant concentration were hypothesized to influence the amount of contaminants offloaded. In other species, older females have been shown to offload significantly fewer contaminants to their offspring compared to younger females[17] and we expected to see a similar pattern. In addition, the amount of contaminants a female acquires prior to a reproductive event might also play a role in the amount she may transfer to young, where females with higher loads may transfer more to their offspring.[18] We explored these relationships by performing a multiple regression using the unstandardized and standardized total loads measured in a litter against female's disk width, liver concentrations, and total liver load. No relationship was found between their liver lipid content and size ($p = 0.57$) or correlation of contaminant concentration with lipid content ($p = 0.25$); therefore, wet weight concentrations were used. However, female's liver weight did increase with size ($F_{1,67} = 266$, $p < 0.0001$, $R^2 = 0.80$). Normalization of the data to mother's body mass was explored but did not alter the observed patterns; outcomes of this analysis were not included in the results.

Since larger females tend to produce larger litters, we might expect offloaded contaminants to show a "dilution effect" since contaminants can be distributed among more offspring. Therefore, we examined the relationship between standardized LN total litter load and number of embryos per litter through linear regression. In addition, if females offload contaminants continuously throughout gestation we expected the amount of contaminants per litter to increase with increasing disk width of embryos. However, since litter load may be related to their mother's concentrations, we first normalized the standardized litter load to mother's total load.

Lastly, we were interested in the types and proportions of contaminants that females transferred to their offspring. Proportions of offloaded PCBs, chlordanes, and DDTs were calculated by dividing the embryo load of each contaminant group by the summed total load (mother and embryo). Offloaded arcsine transformed proportions were then compared with an ANOVA followed by Tukey's posthoc test. A similar GLM as described above was used, except a repeated measures function was included to account for mother-pup pairs to compare the proportions of PCB congener groups.

■ RESULTS

Ova and Eggs. Summed OC loads were significantly higher in eggs (132.6 ± 58.2 ng/egg) than in preovulatory ova (71.63 ± 47.7 ng/ova; $t_{33} = 4.22$, $p < 0.001$; Figure 1). Likewise, the percent of offloaded contaminants was approximately twice as high in eggs compared to ova (0.51 ± 0.23% versus 0.28 ± 0.24%); however, in the multiple regression of LN summed OC load measured in egg and ova tissues significantly increased with their weight ($F_{3,27} = 23.7$, $p < 0.001$, $R^2 = 0.69$). While summed OC load in ova and eggs increased with weight, the proportion of PCBs and pesticide contaminants measured in

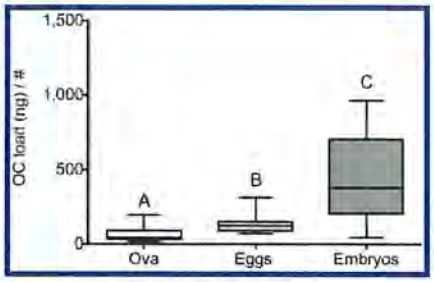

Figure 1. Mean ± SD of summed organic contaminant (OC) load per litter divided by the number of embryos in each litter (no. of litters = 10) were significantly higher (t test, $p = 0.0006$) than summed OC load measured per egg (no. ovulated females = 17), and OC load per egg was significantly (t test, $p < 0.001$) greater than those per ova (no. preovulatory females = 18). Female stingrays from which these tissues were taken had comparable hepatic OC concentrations ($p = 0.91$). Whiskers represent min and max values and different letters represent significant differences.

these tissues did not change with size increase ($F_{1,33} = 0.68$, $p = 0.41$; Table S1). Although eggs were significantly heavier in weight than ova ($t_{31.5} = 3.47$, $p = 0.002$), the percent lipid content was comparable between these two tissues ($t_{19.8} = -0.03$, $p = 0.97$) and there was no relationship between lipid content and measured contaminants ($F_{1,23} = 0.005$, $p = 0.94$). Furthermore, when compared on a lipid weight basis, ova and egg contaminant concentrations were no longer different with the removal of one ova outlier ($p = 0.2$; Table 1). Of the two female related factors used in the multiple regression, only female's contaminant concentrations ($p = 0.025$) demonstrated a significant relationship with the LN OC load in eggs and ova, and no relationship was found with disk width ($p = 0.9$).

Eggs and Embryos. Mean ± SD of summed OC loads measured in eggs were significantly lower than those found in embryos from females of comparable sizes (438.66 ± 301.64 ng/embryo; $t_{25} = 3.9$, $p = 0.0006$; Figure 1). Similarly, the mean percent of offloaded contaminants was significantly greater in late-pregnancy than ovulatory females (1.83 ± 1.58 and 0.52 ± 0.23%; $t_{25} = -4.4$, $p = 0.0002$). While the estimated contaminant load of these females prior to this reproductive event was not different ($p = 0.91$), we did observe a significant decrease in liver lipid content between ovulating and late-pregnancy females ($t_{25} = 2.6$, $p = 0.012$).

Proportions of PCBs, DDTs, and chlordanes were not significantly different between eggs and embryos ($F_{2,67} = 2.36$, $p = 0.10$); however, within these groups proportions by contaminant type differed depending on the number of embryos or eggs sampled per female ($p = 0.008$). As number of embryos or eggs in a "litter" increased, the proportion of PCBs decreased ($p = 0.04$) while the proportion of DDT increased ($p = 0.02$). The mean ± SD of summed OC load of PCBs (636.9 ± 507.9 and 169.1 ± 77.9 ng, respectively), DDTs (46.38 ± 14 and 37 ± 9.2 ng, respectively), and chlordanes (138.4 ± 139.0 and 31.8 ± 13.0 ng, respectively) were significantly higher in embryos than eggs ($p < 0.001$). When PCB proportions were separated by chlorinated congener group, embryos and ova were found to have significantly different proportions for three out of the seven groups ($p < 0.001$, Figure 2A). Eggs had higher proportions of the most chlorinated congeners (nona $p = 0.003$) and least chlorinated congeners (tri, $p < 0.001$). Deca congeners were only measured in egg tissues. Embryos had higher proportions of the less chlorinated congeners (i.e., tetra and penta, $p = 0.06$ and 0.004). Eggs and embryos were similar in proportion for hexa, hepta, and octa congener groups ($p = 0.9$, 0.7, and 0.2).

Mothers and Embryos. While the average percent of offloaded contaminants was relatively low (1.5 ± 1.7%) it was highly variable and showed a decreasing relationship with female size ($F_{1,67} = 6.0$, $p = 0.016$). No relationship was found between average embryo disk width and their mother's liver weight normalized to her disk width ($p = 0.24$). However, the standardized (i.e., per embryo) and unstandardized litter LN contaminant loads showed a positive relationship with their mother's liver contaminant concentration ($F_{3,64} = 10.73$ and

Table 1. Organic Contaminants Measured in the Livers of Pre-Ovulatory and Ovulating Females and Their Ova (Outlier Removed, $n = 17$) and Eggs and Those Found in Embryos and Their Mother's Liver Are Reported as Total Load, Wet Weight Concentration (ww), and Lipid Weight Concentration (lw)[a]

sample	total load (μg/# or μg)	n	% lipid	[ww] (μg/g)	[lw] (μg/g)
Ova	0.07 ± 0.04		5.1 ± 1.9	0.17 ± 0.1	2.9 ± 1.0
Females	27.5 ± 13.9	18	47.8 ± 11	1.4 ± 0.64	3.0 ± 1.4
Eggs	0.13 ± 0.06		9.0 ± 0.59	0.22 ± 0.11	2.5 ± 1.1
Females	43.7 ± 12.3	17	58.0 ± 6.8	1.7 ± 0.5	3.0 ± 1.1
Embryos					
5.0–5.5	0.17 ± 0.14		2.4 ± 3.6	0.21 ± 0.14	8.3 ± 5.6
Mothers	66.9 ± 36.1	12	47.6 ± 8.5	2.4 ± 0.12	4.5 ± 2.2
5.51–6.0	0.32 ± 0.2		2.8 ± 0.85	0.21 ± 0.08	11.6 ± 8.1
Mothers	44.5 ± 7.4	11	44.5 ± 7.4	2.7 ± 0.9	4.7 ± 1.5
6.01–6.5	0.44 ± 0.31		1.8 ± 1.0	0.17 ± 0.09	9.3 ± 7.6
Mothers	132 ± 85	19	45.6 ± 9.0	3.0 ± 1.5	4.8 ± 2.5
6.51–7.0	0.40 ± 0.21		2.5 ± 1.7	0.15 ± 0.07	10 ± 6.2
Mothers	82.9 ± 44.5	12	47.7 ± 11.6	2.6 ± 0.82	3.9 ± 1.3
7.01–7.5	0.80 ± 0.36		3.0 ± 2.4	0.17 ± 0.13	9.6 ± 9.4
Mothers	178 ± 192	7	37.9 ± 20.5	3.9 ± 1.9	5.4 ± 2.6
7.51–8.12	0.68 ± 0.47		1.6 ± 0.7	0.16 ± 0.11	6.3 ± 3.4
Mothers	94.9 ± 53.4	6	48.0 ± 4.3	2.1 ± 0.51	2.7 ± 0.6

[a]Total load represents the product of wet weight (ww) concentration found in the sample multiplied by the weight (g) of tissue analyzed. Ova, eggs, and embryo total loads were standardized to the number sampled from each female or mother (i.e., μg/#).

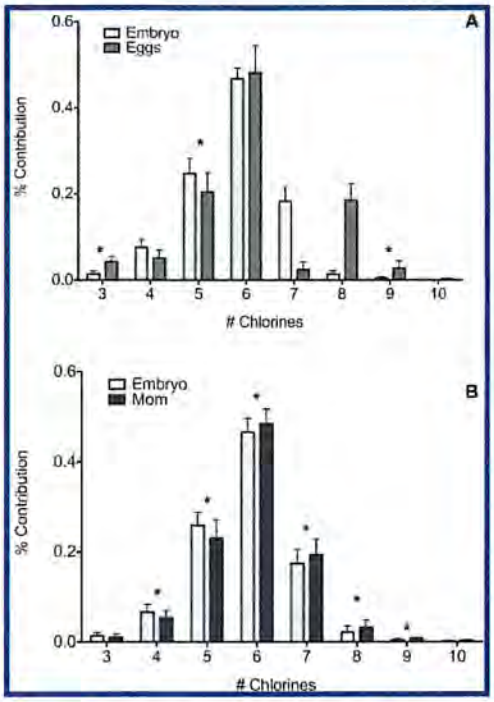

Figure 2. (A) Proportions PCB congener groups in embryos (light gray bars) were similar to those in ovulated eggs (gray bars), except for tri, penta, and nona congener groups. (B) Embryos had significantly higher proportions of tetra and penta PCB congeners compared to their mother's liver (dark gray bars) that had higher proportions of heavier chlorinated PCB congener groups (hexa-nona). Asterisks denote significant differences between embryos and ovulated eggs or mothers.

17.06, $p < 0.0001$, $R^2 = 0.30$ and 0.42; Figure 3). Mother's total load was not significant ($p = 0.12$) and size only showed a

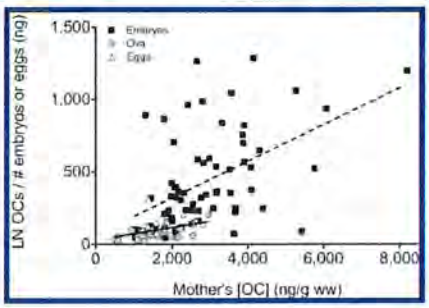

Figure 3. Natural log (LN) of summed OCs (ng) measured per litter per embryo (black triangles) and per ova (gray circles) and egg (gray triangles) showed a significant, positive relationship with increases in their mother's hepatic OC concentration [ww] ($n = 69$, $p < 0.0001$, $R^2 = 0.32$ and $n = 35$, $p = 0.009$, $R^2 = 0.16$, respectively). However, the rate of increase was significantly greater in the embryos (dashed line) than the ova/eggs (solid line; ANCOVA $F_{1,100} = 20.4$, $p < 0.0001$).

positive relationship with litter contaminant loads when they were not standardized per embryo ($p = 0.01$).

While a significant relationship was found between the LN of the total unstandardized litter load and number of embryos in a litter ($F_{1,67} = 5.6$, $p = 0.02$), standardized OC load with respect to litter size was marginally insignificant ($F_{1,67} = 3.5$, $p = 0.06$). Contaminant loads in one litter of near-term embryos (PF-14, $n = 5$) were analyzed individually and all embryos except for one, whose lipid levels were lower than his littermates, showed very little difference in contaminant load (1063 ± 117 versus 603 ng summed OCs; Figure S4). Contaminants measured in litters were also influenced by the stage of gestational development. The LN of standardized embryo load, which were normalized by their mother's liver concentration (i.e., ng/embryo/[mother's OC]), increased as the average disk width for the litter increased ($F_{1,67} = 29.0$, $p < 0.0001$, $R^2 = 0.21$). A nonlinear regression of standardized litter load (normalized to their mother's liver concentration) with embryo size showed a similar pattern to that of the relationship between average litter weight and disk width ($R^2 = 0.38$ and 0.93, respectively; Figure 4). In addition, concentration by lipid weight becomes substantially greater than their mother's as the size class of embryos increased (Table 1).

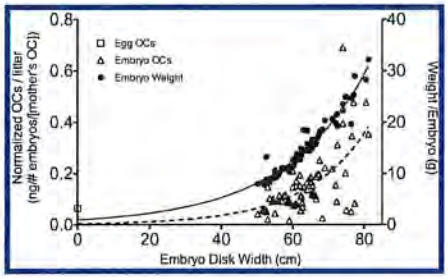

Figure 4. OCs measured per litter per embryo normalized to their mother's liver OC wet weight concentration (open triangles) increased in a nonlinear fashion as the average litter disk width increased (dashed line). In addition, OCs measured in embryos were substantially greater than the average OCs found in eggs (open square). Increases in litter OCs with disk width was similar to the relationship found between average litter weight per embryo and disk width (closed circles, solid line) during the mid to late gestational (no. of litters = 69).

Embryos showed similar contaminant profiles as their mothers in that mean ± SD load of PCBs comprised a majority of the total contaminant load (1062 ± 1012 ng; 81.4 ± 6.2%) with chlordanes representing the next largest contaminant group (194.0 ± 230.9 ng; 14.3 ± 6.9%) followed by DDT (51.2 ± 48.3 ng; 4.2 ± 2.2%; Table S1). However, the LN of the offloaded proportion of these three contaminant groups was significantly different (ANOVA $F_{2,202} = 7.34$, $p = 0.0008$). DDT was found to be offloaded at a higher proportion (2.66 ± 2.68%) compared to PCBs and chlordanes ($p = 0.002$ and 0.003, respectively), while PCBs and chlordanes were comparable (1.46 ± 1.6% and 1.63 ± 2.62%; $p = 0.98$; Figure S). The PCB chlorinated congener groups also showed similar patterns between embryos and mothers, with hexa congeners making up the largest proportion of PCB contaminants when pooled (47.4 ± 3.2%), followed by penta (24.4 ± 3.8%), hepta (18.3 ± 3.5%), tetra (5.9 ± 1.8%), octa (2.7 ± 1.5%), tri (1.3 ± 0.7%), nona (0.64 ± 0.42%), and deca (0.2 ± 0.1%) congener groups. However, the relative proportions of each congener group were different between mothers and embryos for all congener groups ($p < 0.009$) except for tri congeners, which were marginally insignificant ($p = 0.051$, Figure 2B). Embryos were found to have higher proportions of tetra and penta congener groups, while mothers had higher proportions of the more chlorinated groups (i.e., hexa-nona).

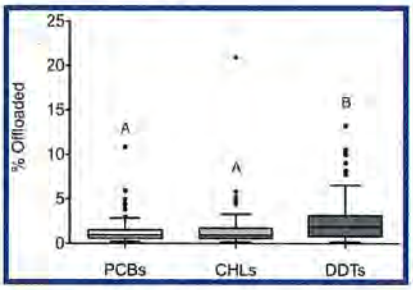

Figure 5. Proportion of offloaded contaminants measured in embryos (n = 69) was significantly different (p = 0.008) among groups with DDT (dark gray) having higher rates than PCBs (light gray) or chlordanes (gray). Boxes represent the first and third quartile and dark lines indicate group means.

DISCUSSION

Female round stingrays were found to maternally offload contaminants to their offspring via two pathways. One route of transfer was through the production of yolky eggs, which embryos utilized during the first third of the gestation period.[14] During the energetic process of vitellogenesis, females redistribute lipids from their livers to ova.[11] Livers are the main energy storage organ in elasmobranchs and thus tend to have the highest contaminant concentrations.[19,20] Therefore, as hepatic lipids are mobilized and transferred to ova contaminants will passively follow. The positive relationship found between ova weight and contaminant load suggests that females continually transfer contaminants to ova throughout their development until ovulation. Given the comparability of ova and egg concentrations on a lipid weight basis suggests that lipid transfer is the vehicle by which contaminants are transferred to these tissues. In addition, females with higher contaminant concentrations transferred higher loads to eggs and ova. Therefore, female's contaminant concentration seems to be an important factor influencing the total amount of contaminants that can be transferred to offspring. Ovulated eggs had significantly higher contaminant loads compared to near ovulation sized ova. Although the percent lipid content did not differ between the two, the larger weight, and therefore total lipid content of ovulated eggs, likely results in greater transfer of these lipophilic contaminants compared to developing ova, which have not yet reached complete maturation.

The second route by which female round stingrays were shown to offload contaminants was through the production of histotroph, or uterine milk,[14] which embryos consumed as a supplemental form of nutrition for a majority of gestation until parturition. The significantly higher loads of summed OCs and greater offloading percent of near-term embryos compared to ovulated eggs demonstrates that females are able to continually transfer contaminants to offspring during gestation. Females of comparable sizes were chosen to remove any potential age influences, since older females would have more time to accumulate contaminants than younger females, which was important to consider since maternal hepatic contaminant concentrations were found to significantly influence the amount of contaminants females offloaded to both eggs and embryos. Assuming homogeneous liver contaminant concentrations, pre-reproductive loads calculated for ovulated and pregnant females were not significantly different in their total contaminant load. Therefore, the higher loads in embryos compared to eggs is due to additional transfer during gestation rather than prior differences in female's contaminant load or size.

While the exact lipid content may vary among species, histotroph is rich in lipids[21] and could result in substantial contaminant transfer. Fatty acids of histotroph measured in two species of rays (butterfly ray, *Gymnura micrura*, and cownose ray, *Rhinoptera bonasus*)[22] were found to be very similar in their composition to those measured in human (*Homo sapiens*) and bovine (*Bos taurus*) milk. Unfortunately, we were unable to measure the contaminant concentrations of histotroph due to uterine flushing by females, which would likely result in lower than actual measured loads. However, late pregnancy females had significantly lower concentrations of hepatic lipids than ovulating females. We assume this decrease in lipid results from continued energetic input, and therefore contaminant transfer, to offspring during gestation, which has been documented in other batoid rays.[23] Since round stingrays undergo continual oogenesis and vitellogenesis it is likely these processes will contribute to the decrease in maternal hepatic lipids as well. However, since developing oocytes in sampled females were small in size (~0.1–0.4 cm diameter), number (n = 1–3), and still at an early developmental stage[14] (K. Lyons, personal observation) the proportion of lipids directed to oocytes versus embryos is expected to be small.

In addition, standardized embryo contaminant load increased in a similar pattern to embryo growth rate as development progressed. This further supports our hypothesis that females transfer contaminants to offspring during gestation at least for the midlate developmental stages. If embryos did not continually accumulate contaminants during development, contaminant loads would decrease as embryos reached parturition size, which was not observed. Furthermore, embryo lipid weight contaminant concentrations were consistently greater than their mother's liver concentrations, which corresponds to similar observations made in marine mammal systems.[7,27] This highlights the transfer of organic contaminants via lipids from mothers to embryos and their subsequent concentration in neonatal tissues. This supplemental provisioning by mothers is important not only for continued embryo growth throughout gestation, but also for the accumulation of energy reserves that offspring will depend on postpartum until they can competently feed on their own.[24] Indeed, embryos further in development had relatively larger livers compared to the weight of other visceral organs (i.e., stomach and spiral valve) than embryos that were less well developed (K. Lyons, unpublished data).

While standardized loads were higher in embryos, the contaminant proportions of PCBs, DDTs, and chlordanes were comparable between eggs and embryos. Therefore, females probably do not transfer these three contaminant groups at different rates during egg formation or throughout pregnancy. Although total PCB proportion was similar, the composition of PCBs by chlorinated congener group was significantly different between eggs and embryos, indicating differential transfer rate at these two points in reproduction (i.e., vitellogenesis and pregnancy). Less chlorinated PCB congeners tend to be more labile and less lipophilic than heavier, more chlorinated congeners.[25] Therefore, the lipophilicity of different PCB congeners will influence their mobility and thus ability to be transferred. Congener groups that had fewer chlorines (tetra and penta) were found in higher proportions in embryos than in eggs. Although very low in proportion and load, the most chlorinated congeners (deca) were only measured in eggs.

Indeed, maternal offloading studies in marine mammals have demonstrated that PCB congeners are transferred at differential rates, with the lighter congeners being transferred more easily.[26−28] In addition, PCB transfer may also be influenced by their affinity for different types of lipids,[29] which may be mobilized at various stages of reproduction.[7] In the round stingray, the types of lipids used for yolk formation may differ between those utilized for histotroph secretion, which could lead to differences in the proportions of contaminants transferred if lipids vary in their hydrophobicity. Since higher proportions of the more chlorinated congeners were found in eggs compared to embryos, this suggests that more nonpolar lipids may be transferred to eggs than during the histotroph phase of gestation, but this remains to be explored.

Maternal hepatic contaminant concentrations appeared to be the most influential factor accounting for contaminant load offloaded to eggs and embryos, regardless if it was standardized by litter size. We may infer that a maternal condition may play an important role in maternal offloading. If females were in a starved or catabolic state, then contaminants would become more concentrated in hepatic tissues as energy stores were utilized. Alternatively, maternal feeding rate and location may influence their contaminant uptake rate, which could lead to higher concentration if it exceeded liver growth rate. In either scenario, subsequent lipid mobilization for reproduction would lead to greater maternal transfer as the amount of contaminants dissolved in those lipids would be higher. In addition, when mothers' liver OC concentrations were normalized to their disk width and liver weight (i.e., [OC]/liver weight/disk width) and compared to the average embryo disk width of the litter a positive relationship was found such that mothers' normalized OC concentrations significantly increased as embryos increased in size during development.

Using disk width as a proxy, age in this study was found to be significant only when unstandardized embryo litter load was used. The explanatory power of age (i.e., disk width) with respect to maternal offloading in this species maybe complicated by the fact that liver growth rate exhibits a linear relationship with disk width (K. Lyons, unpublished data). A contaminant uptake rate that is more or less equal to growth rate may result in rather stable contaminant concentrations despite growth, uncoupling these two variables.

Regardless, the proportion of females' total contaminant load as estimated by the liver that was transferred to offspring was much lower than expected (1.5 ± 1.7%). Since mothers are not fasting during pregnancy, their continued acquisition of dietary contaminants may result in an underestimation of the extent of maternal transfer, to a degree. Contrary to expectation, we found that mother's hepatic OC concentrations increased from the mid to late gestational stages despite the lack of change in female liver weight, which suggests that mother's intake of newly acquired contaminants during gestation was greater than the amount they were offloading. Nevertheless, the results of our study are in stark contrast to maternal offloading studies in other species of elasmobranchs such as white (*Carcharodon carcharias*) and thresher (*Alopias vulpinus*) sharks, which suggest that females transfer a substantial portion of their contaminants to offspring.[12] White and thresher sharks utilize oophagy (where embryos consume unfertilized ovulated eggs throughout gestation[30]), have substantially longer gestational periods, and produce highly developed young.[31,32] Despite differences in supplemental provisioning, round stingrays also have a substantially shorter gestation period and produce young comparatively smaller in size, which would greatly limit the opportunity for females to offload contaminants compared to white or thresher sharks. Given that elasmobranchs demonstrate a wide range of reproductive modes from lecithotrophy to pseudoplacental matrotrophy, varying degrees of maternal investment is likely an important factor influencing the magnitude of maternal transfer in elasmobranchs.

While round stingray females were able to offload more contaminants to larger litters, the amount offloaded per pup in each litter was not related to their mother's size (i.e., age) or the number of siblings in a litter. Since fecundity increases with size in round stingrays as it does in many other species of elasmobranchs, we originally expected embryos from larger females to have fewer contaminants due to (1) hypothesized significant decreases in maternal contaminant concentrations after successive reproductive cycles and (2) a dilution effect due increased number of offspring with concurrent increases in maternal size. The weak relationship between female's size (i.e., age) and hepatic contaminant concentration, which was the most influential factor, was likely the reason the amount of contaminants offloaded per embryo remained relatively constant despite larger litters and older ages in larger sized females. If round stingray females were removing a substantial portion of their contaminants through reproduction, we would expect to see contaminant load per embryo per litter decrease, or become diluted, with increase in litter size, since larger, older females are more fecund, which was not the case.

Although mothers and their embryos showed similar contaminant composition patterns for the three contaminant groups with PCBs comprising a majority, the offloading rates of the three contaminant groups were significantly different. While DDTs made up the smallest portion of the total contaminant load, this contaminant group was offloaded in the highest proportion compared to PCBs and chlordanes. Similar offloading patterns have been observed in many marine mammals species where DDTs are transferred at higher proportions than PCBs[27] due to differences in chlorination, which is related to lipophilicity. The major metabolite of DDT, 4,4′-DDE, which has 4 chlorines, comprised a majority (88 ± 18%, n = 238) of the DDT-related compounds measured. In addition, a large portion of the PCB congeners detected had 6 or more chlorines (70 ± 6%, n = 238). Therefore, the fewer number of chlorines found on 4,4′-DDE compared to PCBs and chlordanes (8−9 chlorines) could make it more easily transferrable and could account for the higher transfer proportion of DDT compared to the other two groups.

The patterns of PCB congener composition found in female and embryo stingrays were similar to those found in other marine organisms such as bottlenose dolphins (*Tursiops truncatus*) from the Gulf of Mexico[26] and ringed seals (*Phoca hispida*) from Canada,[33] highlighting the ubiquity of PCBs despite large geographic separation. However, significant differences between embryos and mothers were found for all PCB congener group proportions, except for tetra congeners. Embryos had higher proportions of tri, tetra, and penta congeners compared to mothers that had higher proportions of the more chlorinated congeners (hexa-deca). These results parallel those found in marine mammal maternal offloading studies.[5,6,26]

Despite the overall low offloading rate of female round stingrays, the loads measured in embryos were substantial and embryos within a litter appear to receive similar amounts of contaminants. While we did not measure any metrics that

might be indicative of negative physiological effects, populations of stingrays in southern California are quite healthy despite the fact that embryos are exposed to potentially harmful chemicals during development and adult females accumulate contaminant loads comparable to higher trophic level elasmobranchs.[34−36] Further studies should continue to explore the dynamic between maternal offloading of contaminants and reproductive mode in elasmobranchs as well as the effect of embryonic and neonatal exposure.

■ ASSOCIATED CONTENT

Supporting Information

Additional data on contaminants and collection sites. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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BRIEF COMMUNICATION

Insights into the life history and ecology of a large shortfin mako shark *Isurus oxyrinchus* captured in southern California

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In June 2013, a record-breaking female *Isurus oxyrinchus* (total length 373 cm, mass 600 kg) was captured by rod and reel off Huntington Beach, California, where it was subsequently donated to research and provided a rare opportunity to collect the first data for a female *I. oxyrinchus* of this size. Counts of vertebral band pairs estimate the shark to have been *c.* 22 years old, depending upon assumptions of band-pair deposition rates, and the distended uteri and spent ovaries indicated that this shark had recently given birth. The stomach contained a *c.* 4 year-old female California sea lion *Zalophus californianus* that confirmed the high trophic position of this large *I. oxyrinchus*, which was corroborated with the high levels of measured contaminants and tissue isotope analyses.

Key words: contaminants; foraging ecology; life history; management.

In the northeastern Pacific Ocean (NEP), shortfin mako sharks *Isurus oxyrinchus* (Rafinesque 1810) are prominent, widespread predators that utilize both coastal and oceanic habitats (Compagno, 2001; Block *et al.*, 2011). While considerable data have been collected on immature specimens, little is known about mature animals,

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particularly females. Data collection on large, mature *I. oxyrinchus* females (280 cm total length, L_T; Joung & Hsu, 2005) is often difficult because these specimens are typically less prevalent, harder to capture, unable to be held in captivity and, unlike the great white shark *Carcharodon carcharias* (L. 1758), they do not form known aggregations. Despite the importance of large females to the reproductive potential of the population (Tsai *et al.*, 2014), very little basic information about mature female *I. oxyrinchus* is available, particularly with regard to morphometrics, reproductive biology, foraging ecology, contaminant loads and age and growth. In the summer of 2013, a 373 cm L_T *I. oxyrinchus* was captured recreationally by hook and line off the coastline of the Southern California Bight (SCB) and subsequently donated to research. The purpose of this paper is to provide insights into aspects of the life history and ecology of *I. oxyrinchus* obtained from this rare specimen.

On 3 June 2013, a female *I. oxyrinchus* was captured by a recreational angler fishing *c.* 24 km off Huntington Beach, California (33·48° N; 118·15° W). The shark was transported to New Fishall Bait Co. (https://www.facebook.com/NewFishallBaitCo) where it was stored chilled (*i.e.* not fully frozen) until necropsy on 9 June 2013. External measurements (straight line and curve lengths) were taken as well as masses of organs at the time of dissection (Tables I and II).

The stomach was cut anteriorly and the fluid inside the stomach was removed, weighed on-site and filtered through a 0·5 mm mesh sieve. The whole stomach and contents were then transported to the National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center (SWFSC), La Jolla, CA, for examination. Materials and fluid were rinsed and sorted through a series of screen sieves with mesh sizes of 9·5, 1·4 and 0·5 mm. The stomach was distended and contained the remains of a California sea lion *Zalophus californianus* (CSL; Fig. 1). By using the skull morphology and teeth annuli, it was possible to determine that the CSL was a juvenile female *c.* 4 years of age (Lowry & Folk, 1990). The mean ± 95% C.I. mass was estimated at 67·6 ± 17·0 kg based on a linear age growth model constructed from wild female CSLs ($n = 26$) that ranged from 2·00 to 3·41 years of age (National Marine Mammal Laboratory, Seattle, WA).

To investigate long-term feeding ecology, stable-isotope analysis (SIA) on white muscle tissue was performed, which in large sharks provides information on the diet over the past year or more (Carlisle *et al.*, 2012). Dorsal muscle tissue was sampled and frozen at −20° C and prepared for analysis (including urea extraction) following the methods of Madigan *et al.* (2012). $\delta^{13}C$ and $\delta^{15}N$ values from this *I. oxyrinchus* were compared with regional prey and predator values from Carlisle *et al.* (2012) and Madigan *et al.* (2012) to subjectively assess whether this individual appeared to largely reflect feeding in the California Current Large Marine Ecosystem (CCLME).

A Bayesian mixing model MixSir (Moore & Semmens, 2008) was used to estimate the relative importance of prey contributions in the CCLME to the diet of this *I. oxyrinchus*. Trophic groupings from Madigan *et al.* (2012) as well as $\delta^{13}C$ and $\delta^{15}N$ from selected marine mammals (Carlisle *et al.*, 2012) were used to assess the contributions of marine mammals, large predators, smaller predators and forage fish to the diet of this *I. oxyrinchus*. One million iterations were run where shark and diet–tissue discrimination factors (DTDF: the difference between shark diet $\delta^{13}C$ and $\delta^{15}N$ values) from large active sharks were used [mean ± S.D. $\Delta^{15}N = 2{\cdot}29 \pm 0{\cdot}22$, $\Delta^{13}C = 0{\cdot}90 \pm 0{\cdot}33$; Hussey *et al.* (2010)]. White muscle $\delta^{13}C$ and $\delta^{15}N$ values for this *I. oxyrinchus* were −16·3 and 17·1‰, respectively (C:N = 3·3). Assuming predation

TABLE I. Various morphometrics of the *Isurus oxyrinchus* taken upon dissection. External measurements were taken over the curve of the body and as a straight line

Measurements	Curve length (cm)	Straight-line length (cm)
Body		
Total stretch	386	383
Total natural	373·5	373
Fork	343	337
Precaudal (to notch)	313	310
Snout to last gill slit	111	101
Snout to dorsal origin	144	139
Snout to vent	244	227
Snout to second dorsal-fin origin		270
First dorsal-fin origin to second origin	132	130
Snout to anal-fin origin	290	275
Snout to left pectoral-fin origin	100	89
Snout to orbit	25	
Snout to nare	16	
Nare to nare	17·2	
Girths		
Anterior to dorsal origin	238	
Posterior to pectoral-fin insertion	209	
Anterior to pelvic-fin origin	150	
Fins		
Width across keel	32	
Dorsal fin		
Height from midline	35·5	
Height from origin	44	
Origin to free rear tip width	43	
Origin to insertion width	37	
Pectoral fin		
Origin to tip	65	
Widest width	39	
Origin to insertion width	30	
Caudal fin		
Width (origin to fork)	26	
End of keel to fork	23	
Length of superior caudal fin	66	
Length of inferior caudal fin	52	
Height (tip to tip of caudal)	98	
Pelvic fin		
Origin to insertion	22	
Origin to free rear tip	26	
Width of left pelvic fin	10	
Gill slits		
Length of fifth gill slit	35	
Length of fourth gill slit	32	
Length of third gill slit	31	
Jaws		
Midline of upper jaw to left joint	29·8	
Gape (joint to joint)	25	
Eye diameter	4·6	
Reproductive		
Uteri length (R, L)	90, 89	
Uteri width (R, L)	15, 15	
Shell gland length (R, L)	8, 8	
Shell gland width (R, L)	5·3, 5	

R, right; L, left.

TABLE II. Mass of internal organs of *Isurus oxyrinchus* taken at the time of dissection. Total mass of the animal was obtained from an International Game Fish Association (www.igfa.org) certified scale at the time of landing

Organ	Mass (kg)
Total	600·11
Liver	56·70
Left liver lobe	29·03
Right liver lobe	27·67
Reproductive tract (ovaries and uterus)	4·97
Heart	0·73
Pancreas	0·39
Total mass of stomach and contents	95·30
Stomach fluid removed	67

primarily in the CCLME, these values indicate a high trophic level for this *I. oxyrinchus* based on comparison of δ^{13}C and δ^{15}N values with other CCLME predators (Madigan *et al.*, 2012). δ^{13}C and δ^{15}N values were higher than those of other pelagic predators (billfish, tunas, jacks and small sharks) in the CCLME (Madigan *et al.*, 2012) but lower than those of marine mammals and *C. carcharias* in the CCLME (Carlisle *et al.*, 2012; Fig. 2). Estimated prey (with ranges) contributions to the *I. oxyrinchus* diet were marine mammals 29% (5–55%), large predators 24% (2–70%), smaller predators 18% (2–56%) and forage fishes and squids 18% (2–47%).

FIG. 1. Remains of the *Zalophus californianus* found in the *Isurus oxyrinchus* stomach. Photo credit: Rocky Kasler

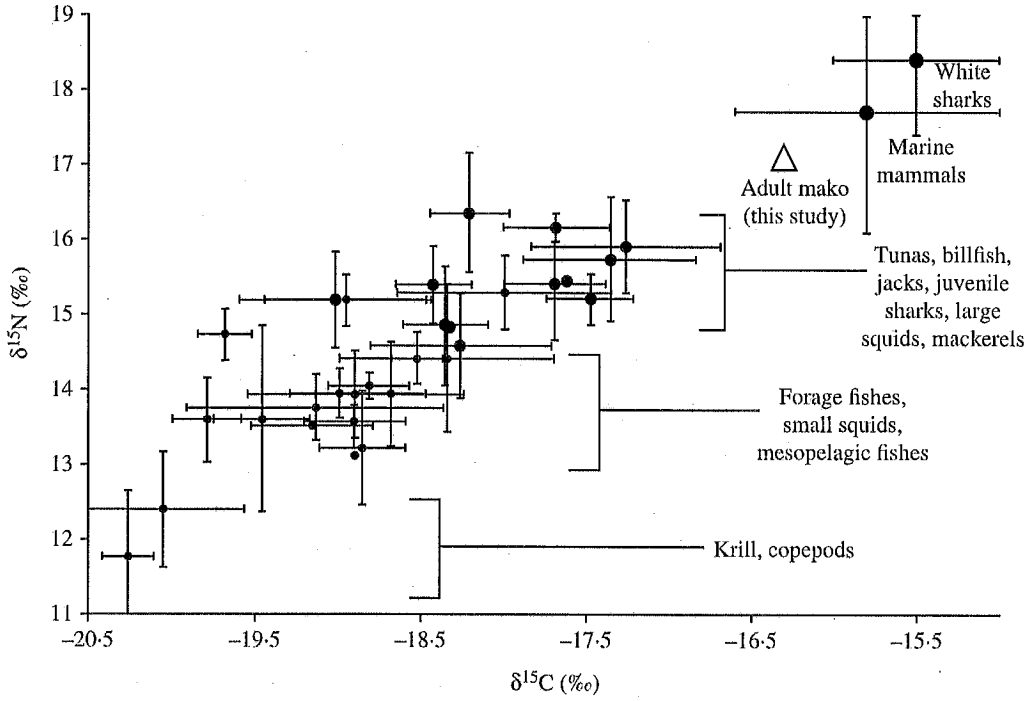

FIG. 2. δ^{13}C and δ^{15}N values (mean ± S.D.) for pelagic predators (●) and prey (•) in the California Current Large Marine Ecosystem. The large adult *Isurus oxyrinchus* of this study is represented (△). Pelagic predator and prey data from Madigan *et al.* (2012); *Carcharodon carcharias* data from Carlisle *et al.* (2012); marine mammal data are for *Phocoena phocoena* (Toperoff, 2002) and *Mirounga angustirostris*, *Phoca vitulina* and *Zalophus californianus* (Burton & Koch, 1999).

Spiral valve parasites are generally diet related and can also provide information on the diet of a shark over a longer period than the classification of identifiable food items in the gut. The spiral valve was cut open longitudinally along the line of the main blood vessel to reveal the inner lumen. All parasites found were fixed in 10% formalin and sent to the University of Aberdeen, Scotland, U.K., for identification. Three types of helminth parasite were found: 20 specimens of the tetraphyllidean tapeworm *Ceratobothrium xanthocephalum*, two of a trypanorhynch tapeworm of the family Tentaculariidae and some fragments of *Capillaria* spp. nematodes. *Ceratobothrium xanthocephalum* has been previously reported from an *I. oxyrinchus* caught off Montauk, New York (Olson *et al.*, 1999), but this is the first record from *I. oxyrinchus* for the Pacific Coast of North America. Nematodes of the genus *Capillaria* are parasites of teleosts and thus indicate predation on bony fishes.

Vertebral band-pair counts were used to estimate the age of this *I. oxyrinchus*. Vertebral centra were extracted from between the gills and the first dorsal fin and sectioned through the middle along the sagittal plane into bow-tie sections. Two methods were used to identify band pairs in the centra: (1) high frequency x-radiography (Cailliet & Bedford, 1983; Wells *et al.*, 2013) and (2) light microscopy (Bishop *et al.*, 2006; Natanson *et al.*, 2006). Both the x-radiography and light microscopy methods yielded similar counts of 26–28 band pairs (post-birth band), and all readers collectively discussed the images and agreed to a consensus count of 27 band pairs (Fig. 3). The periodicity of band-pair deposition for *I. oxyrinchus* in the NEP up to age 5 years has been validated

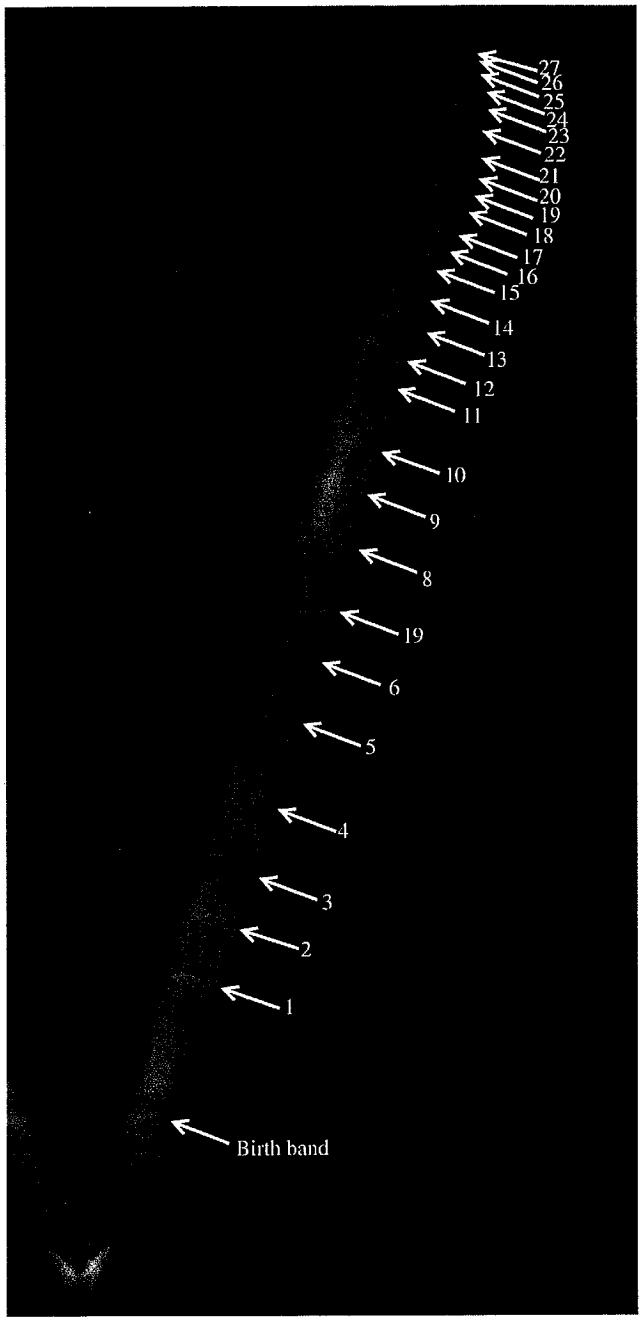

FIG. 3. Cross section of vertebra from the *Isurus oxyrinchus* with band pairs indicated by arrows.

at two band pairs per year based on oxytetracycline tagging (Wells *et al.*, 2013). In the Atlantic, bomb radiocarbon dating has shown that *I. oxyrinchus* probably deposits a single band pair per year, although the data did not preclude two band pairs being deposited in the first few years (Campana *et al.*, 2002; Ardizzone *et al.*, 2006). As this large *I. oxyrinchus* was caught in southern California waters, a band-pair deposition rate of two per year was assumed for the first 5 years switching to one per year thereafter; hence, the age was provisionally estimated to be 22 years.

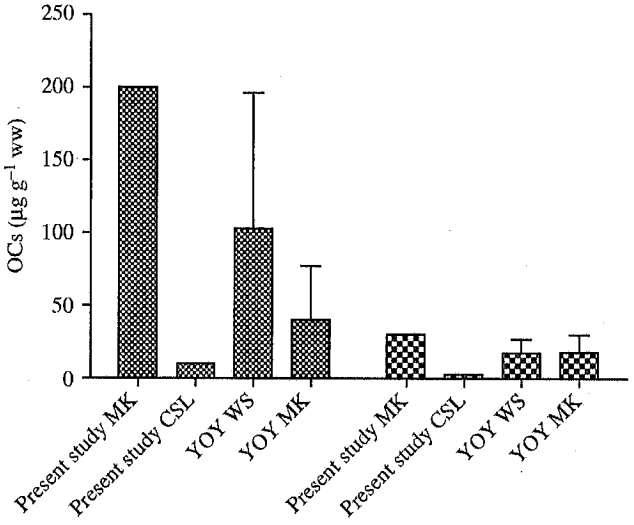

FIG. 4. Organochlorine (OC) concentrations (wet mass) for dichlorodiphenyltrichloroethanes (DDT) (▩) and polychlorinated biphenyls (PCB) (▩) measured in the liver of the *Isurus oxyrinchus* (present study MK) and the blubber of the ingested *Zalophus californianus* (present study CSL) compared with levels previously measured in young-of-the-year (YOY) *Carcharodon carcharias* (WS) and *I. oxyrinchus* (MK; Lyons *et al.*, 2013).

The reproductive organs were removed from the animal, weighed and various lengths and widths were measured (Table I). The uteri were distended and flaccid and contained a small volume of a thick, yellowish fluid. Uterine widths were similar to those reported for post-partum females in other studies (Mollet *et al.*, 2000). The internal linings of the uteri were enfolded. The ovaries contained many small (*c.* 0·5 cm) atretic ova and appeared to be recently post-partum (L. Natanson, pers. comm.).

Dichlorodiphenyltrichloroethane (DDT) and its metabolites (dichlorodiphenyl dichloroethylene, DDE and dichlorodiphenyldichloroethane, DDD), along with 54 congeners of polychlorinated biphenyls (PCB), and chlorinated pesticides were measured in the liver (distal part of left lobe) of the shark and blubber (cervical region) from the CSL following methods of Lyons *et al.* (2013). Because of the high concentration of 4,4′-DDE initially measured in the hepatic tissue, the sample was diluted 1:40 for comparison with the standard curve. Two pairs of blank spikes, one pair of sample replicates, one certified reference material (CRM; Lake Trout Tissue 1947) and one blank were run in tandem with samples to ensure accuracy and precision. The per cent recovery of compounds was high (mean ± S.D.) in the blank spikes (96 ± 17%), CRM (102 ± 13%) and recovery surrogates (100 ± 21%), and the relative S.D. among all replicates was low (3 ± 3%). Approximately 0·5 g of white muscle was analysed for mercury following the methods of Lyons *et al.* (2013).

DDTs were the most prominent class of organic contaminants measured in the liver, comprising 86% of the total, with the 4,4′-DDE being the most concentrated compound [200 and 250 μg g^{-1} wet (ww) and lipid (lw) mass, respectively). Assuming homogenous concentrations of organic contaminants throughout the liver, *c.* 11·4 g of DDT compounds were estimated to be in the liver. PCBs (30 and 37 μg g^{-1} ww and lw,

respectively) comprised 13% of the total contaminant load. The contaminant concentrations in the CSL blubber were lower than those found in the liver when compared on a wet-mass basis (Fig. 4), but not on a lipid-mass basis. The ratio of [DDTs]:[PCBs] can be used to describe the relative proximity of an animal's food source to coastal California contamination point sources (*e.g.* the Palos Verdes Shelf Superfund site located 3 km offshore in Los Angeles County, CA) with higher ratios indicating closer proximity to the site. The DDT:PCB ratio was higher in the *I. oxyrinchus* (6·6) than it was in the sea lion (4·0). Mean ± S.D. total mercury measured in the muscle tissue of the *I. oxyrinchus* was $20{\cdot}8 \pm 0{\cdot}8\ \mu g\ g^{-1}$ wet mass, averaging across three replicates.

The trophic ecology of this large *I. oxyrinchus* was examined using stomach content analysis, SIA and contaminant signatures. These three methods consistently indicated that the *I. oxyrinchus* foraged at a high trophic level and that marine mammals were part of its diet. These results are not uncommon for large *I. oxyrinchus* in the NEP as previous examinations have documented the presence of pinnipeds in the stomachs of large female sharks in this region. In a separate series of studies conducted at the SWFSC, A. Preti and D. Kacev (unpubl. data) documented the presence of pinnipeds in the stomachs of five large (>296 cm) female *I. oxyrinchus*, and D. B. Holts and D. A. Ramon (unpubl. data) found the remains of a harbour seal *Phoca vitulina* and small odontocete in a large *I. oxyrinchus* caught near Santa Barbara Island, California. While it is difficult to determine whether the consumed CSL was the result of an attack or scavenging event, long streaking lesions on the CSL remains suggest an active attack. The rise in NEP pinniped populations probably provides a high quality food source for these large *I. oxyrinchus* (Carretta *et al.*, 2014). As smaller-sized *I. oxyrinchus* (<280 cm L_T) feed primarily on teleosts and squids (Preti *et al.*, 2012), it is possible that the role this species plays in local ecosystems may change with ontogeny as different food items are incorporated into the diet.

Mixing model estimates, by using prey data from the CCLME, rely on the assumption that this *I. oxyrinchus* was primarily a CCLME predator. It had higher $\delta^{13}C$ and $\delta^{15}N$ values than other pelagic predators in the CCLME (Madigan *et al.*, 2012), but lower values than marine mammals and adult *C. carcharias* (Carlisle *et al.*, 2012). Based on tagging data of other large *I. oxyrinchus* (Kohler *et al.*, 2002; Block *et al.*, 2011), it is likely that this *I. oxyrinchus* made seasonal forays into oligotrophic waters as do adult *C. carcharias* (Carlisle *et al.*, 2012). The relative influence of prey type and foraging locations cannot be determined as prior movements are unknown. Offshore feeding in oligotrophic regions, however, would decrease $\delta^{13}C$ and $\delta^{15}N$ values of this *I. oxyrinchus*; thus, the SIA-based trophic position of this *I. oxyrinchus* is a conservative estimate (Fig. 2).

Southern California's unique DDT signature can be used to infer proximity of feeding to this coastal location. The higher DDT:PCB in this *I. oxyrinchus* than the consumed CSL and young-of-the-year *C. carcharias* (which acquire their signal maternally; Lyons *et al.*, 2013) was unexpected. Typically, CSLs and juvenile *C. carcharias* are nearshore and would thus be expected to have higher ratios than the generally more pelagic *I. oxyrinchus*. The ratio in the *I. oxyrinchus*, however, was lower than that found in white croaker *Genyonemus lineatus* (Ayres 1855) sampled directly from the Palos Verdes Shelf Superfund Site where ratios ranged from 15 to 22 (Gossett *et al.*, 1983). This strong coastal SCB DDT:PCB signature in the *I. oxyrinchus* could be explained by greater utilization of inshore waters than previously thought or by consumption of coastally associated prey that had ventured offshore.

Age and growth studies have generally been limited to smaller, younger specimens, which has made it difficult to estimate life span of the long-lived *I. oxyrinchus*. The large size of this *I. oxyrinchus* has provided a valuable data point that will give greater certainty to the upper end of growth curves, which is important for assessing the species' productivity and abundance and implementing appropriate management practices (Hoenig & Gruber, 1990). The exact age of this animal was uncertain due to the unresolved band-pair deposition rates across regions, ages and sexes for NEP *I. oxyrinchus*. Given the uncertainty in band-pair deposition rates for adults in the NEP, the specimen examined could be as young as 13·5 years if biannual band-pair deposition continues throughout life, or could be between the estimated ages of 13·5 and 22·0 years if an ontogenetic shift in banding periodicity occurs sometime after 5 years (Wells *et al.*, 2013). The size and estimated age range of this *I. oxyrinchus* fall near the top of the previously aged *I. oxyrinchus* in the Pacific Ocean as does the number of band pairs counted; however, some similarly sized sharks in the Atlantic have had as many as 32 vertebral band pairs, which were thought to be reflective of an annual deposition pattern based on bomb radiocarbon dating, suggesting a difference in growth rates and size at age between oceans (Cailliet & Bedford, 1983; Ardizzone *et al.*, 2006; Bishop *et al.*, 2006; Natanson *et al.*, 2006; Semba *et al.*, 2009; Doño *et al.*, 2015; H. H. Hsu, unpubl. data).

Previous reproductive studies of *I. oxyrinchus* have suggested that they reproduce every 2–3 years, with an estimated gestation of 12–25 months (Pratt & Casey, 1983; Mollet *et al.*, 2000, 2002; Joung & Hsu, 2005) followed by a rest period before the next pregnancy begins (Stevens, 2008). The lack of ovarian activity (*i.e.* ripe or developing ova 0·6–0·8 cm; Mollet *et al.*, 2000), presence of yellowish fluid in the distended uteri, spent ovaries with many atretic ova and the enfolded rather than smooth uterine lining suggest that this *I. oxyrinchus* had recently given birth and had not started her resting period at the time of capture. *Isurus oxyrinchus* are thought to pup from late winter to mid spring (Mollet *et al.*, 2000; Joung & Hsu, 2005). This post-partum female was caught in early June in the SCB, near the end of the purported pupping season. Since the SCB is a putative nursery, her presence in this area could have been for reproductive reasons in addition to feeding.

While the potential health effects of contaminants on sharks are not known, there are known concerns about human consumption of contaminants. The DDT and PCB concentrations present in the liver of the present specimen were nearly 100 and 250 times greater, respectively, than the no-consumption limit based on values developed by the US Environmental Protection Agency (Klasing *et al.*, 2009). Also, the high mercury loads measured in the muscle greatly surpass by *c.* 20-fold the US Food and Drug Administration's action level of $1{\cdot}0\,\mu g\,g^{-1}$ ww (USFDA, 2000), above which legal action will be taken to remove products from the market. Based on a 227 g (8 oz) serving size and using advisory tissue levels from Klasing *et al.* (2009), the levels measured in the *I. oxyrinchus* were *c.* 45 times greater than the no consumption level for women of child-bearing age and children and *c.* 15 times greater for women over 45 and men.

Valuable information was obtained from this animal on age and growth, reproduction, morphometrics and foraging ecology. This single specimen provided insights into the behaviour and ecology of large *I. oxyrinchus* in southern California ecosystems. Results from feeding ecology analysis suggest that both pinnipeds and coastal prey were components of the diet. High trophic level feeding coupled with a relatively old age contributed to high contaminant levels in this *I. oxyrinchus*. Although considered

rare, large *I. oxyrinchus* are caught in recreational fisheries in southern California, a fishery with considerable effort. Based on the present findings, large sharks like the specimen studied may spend protracted periods in coastal pelagic habitats (<20 km from the shore) where they may be vulnerable to capture in recreational fisheries. By understanding their habitat use and potential sources of mortality, especially for larger females, more reliable population assessments and appropriate management efforts can be achieved.

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State of California
Department of Fish and Wildlife

Memorandum

Date: July 18, 2017

To: Valerie Termini
Executive Director
California Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Petition #2016-020: Ban Recreational Fishing of Sharks and Rays Using Bow and Arrow and Harpoon Gear**

The Department of Fish and Wildlife (Department) has reviewed the above-referenced petition and recommends the Fish and Game Commission decline to act on the request. As described below, the Department's evaluation indicates that the requested ban is not likely to effectively address the shark conservation concerns raised in the request.

Background

In October 2016, the Fish and Game Commission (Commission) received a petition requesting a change to Title 14 CCR, §28.95 to disallow harpoon and bow and arrow as legal gear types for the recreational take of sharks and rays. The regulation currently allows the use of spears, harpoons and bow and arrow for taking all varieties of skates, rays, and sharks, except White Sharks (*Carcharodon carcharias*).

The petition states that bow and arrow fishing for sharks "is a form of hunting, not fishing, and baiting is considered unethical and illegal in the realm of hunting" and that this practice should be made illegal for several reasons. The petition claims that bow and arrow fishing is not sporting; that sharks are slow growing with low reproduction; that bow hunting targets the largest sharks, killing off the mature breeding population; and that sharks of this size have high toxin loads, cannot be eaten, and using this method cannot be released. The petition also states that "…current laws do not adequately protect the sharks."

Department Evaluation

Several species of pelagic shark, including Shortfin Mako (*Isurus oxyrinchus*), Common Thresher (*Alopias vulpinus)*, and Blue Shark (*Prionace glauca)*, are common in waters off California. Recreational bow and arrow fishing for these species occurs in California, though at very low rates. Some nearshore shark species, such as Leopard Shark (*Triakis semifasciata*), while not mentioned in the petition, are targeted recreationally with bow and arrow from the shoreline. There is no known recreational harpoon fishery for sharks in California, though they are occasionally taken by spear. The petition is not specific in regards to spear fishing, but could potentially extend to it.

Contrary to the assertion that current laws do not adequately protect sharks, these sharks are actively managed under current fishing regulations. Recreational bag limits allow only two Shortfin Mako, Common Thresher, and Blue Shark (Title 14 CCR, §28.42) and three Leopard Shark (Title 14 CCR, §28.56) per angler per day. Leopard shark have a minimum size limit of 36 inches. These species are also managed under Federal Fishery Management Plans and none are designated as overfished or experiencing overfishing.

The use of attractant, in the form of chum, is also legal and commonly used by hook and line anglers to pursue many species, including sharks (Title 14 CCR, §27.05). Chum, unlike mammal bait on land, disperses rapidly, does not create a permanent "feeding station", and does not increase the chance of disease spread or predation that may occur on land.

Bow fishing is more common in freshwater and is considered both sporting and fair. By its nature, this form of tackle does not allow for catch and release fishing, but for the same reason it is very target specific. Since each fish is individually sighted, the gear greatly reduces the likelihood of catching a non-target species and has low or no bycatch. Though this gear type may be growing in overall popularity, its current use by saltwater anglers to catch sharks appears to be limited. Fishing for pelagic shark by this method is known to occur on a small number of chartered fishing trips and private vessels.

While it is well documented that large marine predators can carry significant biological loads of heavy metals and other organic contaminants in their tissues, the potential for human health issues related to the consumption of large sharks taken by bow and arrow does not differ from sharks taken by hook and line. The California Office of Environmental Health Hazard Assessment provides guidelines on fish consumption to reduce risk of chemical exposure[1]. The U.S. Food and Drug Administration and the U.S. Environmental Protection Agency also monitor seafood safety and have issued advice about eating fish and shellfish[2]. These existing advisories provide consumers with appropriate guidance on the potential risks of consuming sharks and other seafood.

Based on evaluation of the petition and supporting documents, the CDFW does not support the proposed change to sport fishing regulations found in Title 14 CCR, §28.95 to disallow bow and arrow, and harpoon as legal gear types for the recreational take of sharks and rays. This recommendation is based on the following findings:

- The use of harpoons, spears and bow and arrow gear is legal and is not equivalent to terrestrial hunting. There is no evidence that these gears are increasing take or creating overfishing.

[1] https://oehha.ca.gov/fish/advisories
[2] https://www.epa.gov/fish-tech/2017-epa-fda-advice-about-eating-fish-and-shellfish

- Chumming is allowed in ocean waters for recreational fishing, without restriction on target species or tackle. Changes to restrictions on chumming could have widespread implications.
- Recreational fishing for Mako, Blue, Thresher, and Leopard sharks is restricted by daily bag and possession limits to protect the species from overfishing.
- Bow and arrow fishing, while not allowing for catch and release, is highly selective and has little or no bycatch
- The use of bow and arrow does not change potential health risks associated with consuming large marine predator species.

If you have any questions or need additional information about the Department's recommendation to deny this petition, please contact Dr. Craig Shuman, Marine Regional Manager by telephone at (805) 568-0216, or by email at Craig.Shuman@wildlife.ca.gov.

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