12. NORTHERN CALIFORNIA SUMMER STEELHEAD

Consider whether listing northern California summer steelhead (*Oncorhynchus mykiss irideus*) as threatened or endangered under the California Endangered Species Act (CESA) may be warranted.

Summary of Previous/Future Actions

- Received petition — Sep 28, 2018
- FGC staff transmitted petition to DFW — Oct 8, 2018
- Published notice of receipt of petition — Oct 26, 2018
- Public receipt of petition and approval of DFW's request for a 30-day extension — Dec 12-13, 2018; Oceanside
- Received DFW 90-day evaluation — Feb 6, 2019; Sacramento
- **Today determine if petitioned action may be warranted** — **Jun 12-13, 2019; Redding**

Background

In Sep 2018, FGC received a petition (Exhibit 1) from Friends of the Eel River to list California summer steelhead as endangered under CESA. The petition was formally received by the public at the Dec 2018 FGC meeting.

California Fish and Game Code Section 2073.5 requires that DFW evaluate the petition and submit to FGC a written evaluation with a recommendation, which was received at FGC's Feb 6, 2019 meeting (Exhibit 3). The report delineates each of the categories of information required for a petition, evaluates the sufficiency of the available scientific information for each of the required components, and incorporates additional relevant information that DFW possessed or received during the review period.

Based upon the information contained in the petition and other relevant information, DFW has determined that there is sufficient scientific information available to indicate that the petitioned action may be warranted (Exhibit 2).

Today's agenda item follows the public release and review period of the evaluation report, as required in Fish and Game Code Section 2074 prior to FGC action. If FGC determines listing may be warranted pursuant to Section 2074.2 of the Fish and Game Code, a one-year status review will commence before a final decision on listing is made.

CESA and FGC's listing regulations require that the petition contain specific scientific information related to the status of the species. CESA, and case law interpreting it, make clear that FGC must accept a petition when the petition contains sufficient information to lead a reasonable person to conclude that there is a substantial possibility the requested listing could occur; the requested listing is tied to the species' status, that is, whether the species' continued existence is in serious danger or is threatened by a number of factors, and in no way relates to economic consequences that might result from listing.

Significant Public Comments (N/A)

Recommendation

FGC staff: Determine that listing may be warranted.

DFW: Accept and consider the petition for further evaluation.

Exhibits

1. Petition, received on Sep 28, 2018
2. DFW memo, received Jan 24, 2019
3. DFW 90-day evaluation report, dated Jan 2019

Motion/Direction

Moved by _____ and seconded by _____ that the Commission, pursuant to Section 2074.2 of the Fish and Game Code, finds that the petition to list northern California summer steelhead as endangered species **does** provide sufficient information to indicate that the petitioned action **may be** warranted based on the information in the record before the Commission, and directs staff to issue a notice reflecting this finding and that northern California summer steelhead is a candidate for threatened or endangered species status.

OR

Moved by _____ and seconded by _____ that the Commission, pursuant to Section 2074.2 of the Fish and Game Code, finds that the petition to list northern California summer steelhead as an endangered species **does not** provide sufficient information to indicate that the petitioned action may be warranted based on the information in the record before the Commission.

From: Scott Greacen <scott@eelriver.org>
Sent: Friday, September 28, 2018 3:40 PM
To: FGC
Subject: Petition to list Northern California summer steelhead under CESA
Attachments: FOER NC summer steelhead CESA petition.pdf

Dear Ms Miller-Henson

I am submitting the enclosed petition by regular mail as well this afternoon.

Thank you for your work to protect California's natural heritage.

Scott Greacen
Conservation Director
Friends of the Eel River

scott@eelriver.org
707/502.4555 mobile

FGC – 670.1 (3/94)

A PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION

For action pursuant to Section 670.1, Title 14, California Code of Regulations (CCR) and Sections 2071 and 2073 of the Fish and Game Code relating to listing and delisting endangered and threatened species of animals and plants.

I. SPECIES BEING PETITIONED:

Common Name: Northern California Summer Steelhead

Scientific Name: *Oncorhynchus mykiss irideus*

II. RECOMMENDED ACTION:

(Check appropriate categories)

a. List **X**

b. Change Status

As endangered ___X___ From _____

As threatened _____ To _____

c. Or Delist

III. AUTHOR OF PETITION

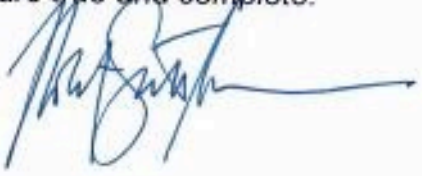
Name: Scott Greacen

Address: POB 4945
Arcata, CA 95518

Phone Number: (707) 798-6345

I hereby certify that, to the best of my knowledge, all statements made in this petition are true and complete.

Signature:



Date: September 27, 2018

FRIENDS OF THE EEL RIVER

Working for the recovery of our Wild & Scenic River, its fisheries and communities.

Friday, September 28, 2018

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

Dear Commissioners,

This is a petition to list Northern California summer steelhead under the California Endangered Species Act, (CESA, FGC § 2050 et seq.), as an endangered species.

Under CESA, "Endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease. (F&GC § 2062)

Northern California summer steelhead (NC summer steelhead) are a native subspecies of fish in serious danger of becoming extinct throughout all of its range due to causes including loss of habitat and change in habitat.

These extraordinary fish are superlative in many ways. They include the largest adult steelhead, as well as fish capable of handling the highest water velocities and of jumping the highest barriers of any salmonids. NC summer steelhead include the southernmost summer steelhead. They are able to tolerate water temperatures higher than any other anadromous salmonids.

In their recent comprehensive review of the status and threats to salmonids in California, Moyle et al assessed the status of NC summer steelhead as being of Critical Concern, with a Status Score of 1.9 out of 5.0:

> *Northern California (NC) summer steelhead are in long-term decline and this trend will continue without substantial human intervention on a broad scale. Due to their reliance on cold water to over summer during the warmest months in freshwater and critical susceptibility to climate change, NC summer steelhead are vulnerable to extinction by 2050.* (p. 276.)

Recent genetic research has demonstrated that a specific mutation gave rise to early-migrating life histories in both steelhead and chinook. These extremely rare evolutionary events are conserved in populations of summer steelhead and spring-run Chinook salmon today. However, if those premature-migrating populations are lost, the genetic diversity that makes the life history possible will itself be lost.

In its capacity as steward of the public trust in California's fish and wildlife heritage, the Fish and Game Commission should recognize and protect NC summer steelhead under CESA. We encourage the Commission to work with the Department of Fish and Wildlife to

HUMBOLDT OFFICE
foer@eelriver.org
PO Box 4945, Arcata, CA 95518 • 707.798.6345

NORTH BAY OFFICE
David Keller, dkeller@eelriver.org
1327 I Street, Petaluma, CA 94952 • 707.763.9336

further focus future conservation actions on NC summer steelhead, and to secure the resources necessary to protect these fish while we still have them.

In the following, the bracketed letters refer to the list of scientific information required of a petition to the Commission under 14 CCR § 670.1(d)(1).

(A) population trend and (D) abundance;

As noted, Moyle et al assess NC summer steelhead populations as being in long-term decline. They note that "Little historical abundance information exists for naturally spawning populations of NC summer steelhead, but current abundance of this species is likely much less than historical estimates." (p. 277)

The species persists in only a handful of watersheds. In only a few of those do we have evidence of even a hundred fish in a year. Moyle et al estimate that there are likely "fewer than 1,000 adults across the DPS in a given year." (p. 287)

In its most recent status review for the NC steelhead DPS, NMFS concluded that while winter-run steelhead populations are relatively healthy, and the DPS as a whole does not appear, in the agency's opinion, to face an increased risk of extinction, "(s)mmer-run populations continue to be of significant concern. While one run is near the viability target, others are very small or there is a lack of data." (NMFS 2016 Five Year Status Review, p. 41)

The one population "near the viability target" is the Middle Fork of the Eel River. It is also in long-term decline.

> *The Middle Fork Eel also had summer steelhead arriving as early as April 20th in some years and supported good numbers of fish (DFG 1959). It was once home to what was considered the largest run of summer steelhead left in the basin (DFG 1999). CDFW has conducted snorkel and electrofishing surveys on the Middle Fork since 1966, with survey data showing a downward trend in abundance and relatively low fluctuating numbers of fish over the last five decades (Figure 4).* (Moyle p. 279)

NMFS note that "...the Van Duzen River appears to be supporting a population numbering in the low hundreds. However, the Redwood Creek and Mattole River populations appear small, and little is known about other populations including the Mad River and other tributaries of the Eel River (*i.e.*, Larabee Creek, North Fork Eel, and South Fork Eel). (NMFS 2016 Five Year Status Review p 41) Moyle et al present survey data from the Mad River that suggests that watershed could support several hundred fish. However, Moyle et al point out that "NOAA Fisheries forecast that NC summer steelhead populations in the Redwood Creek, Van Duzen River, North and South Fork Eel, and Mattole are all highly susceptible to climate change impacts in the near future."

It may be possible to restore an additional population of NC summer steelhead to the Upper Mainstem Eel River, but only by restoring fish passage that has been blocked for a century by Scott Dam. NMFS' MSRP states: "The Upper Mainstem Eel River steelhead population was once the longest-migrating population in the entire DPS. Restoring access to historical habitat above Scott Dam is essential to recovering this population." (p. 466)

(B) range and (L) a detailed distribution map;

NOAA Fisheries (NMFS), in their 2016 Coastal Multispecies Recovery Plan (MSRP), outline the range of NC summer steelhead in Volume III. Figure 2 on p. 4 of that volume is reproduced below; it displays the NC summer steelhead range. It includes the larger coastal watersheds from Redwood Creek south to the Mattole River, including the Mad River and various tributaries of the Eel River. Please note that the MSRP includes highly detailed maps of all Northern California summer steelhead watersheds. We hereby incorporate those materials and the remainder of the MSRP by reference into this petition.

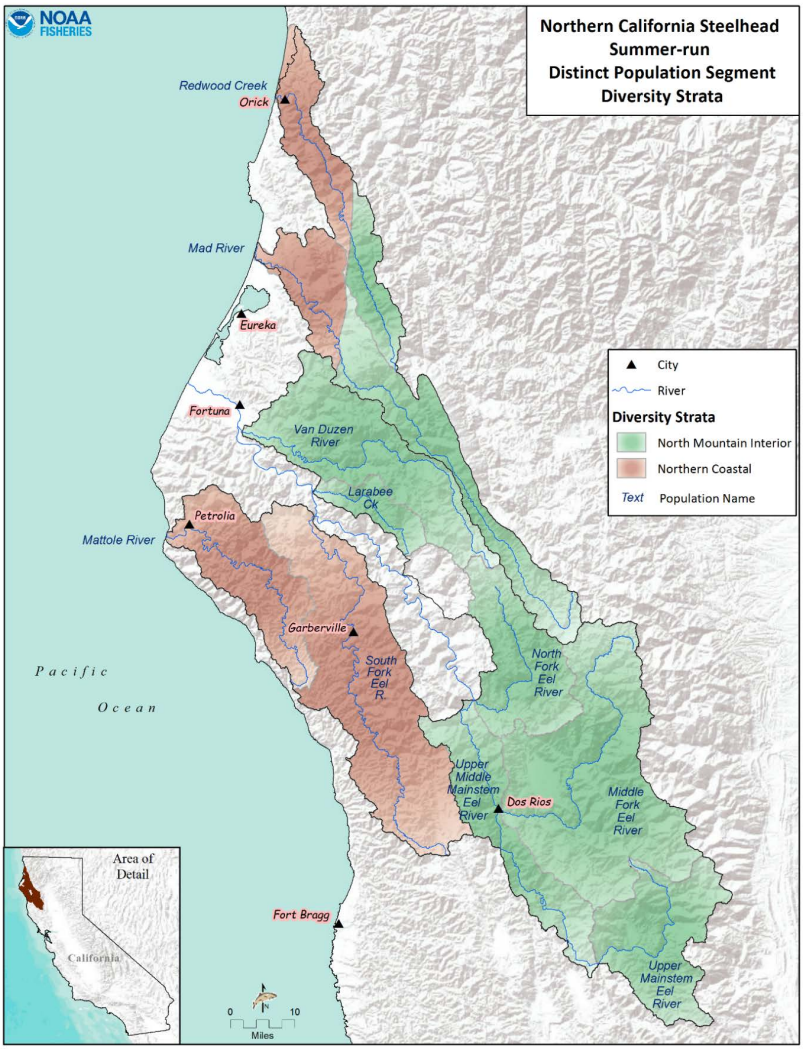


Figure 2: NC Steelhead Summer-Run Populations and Diversity Strata boundaries.

However, this classification leaves another group of native California summer steelhead, the Klamath Mountain Province summer steelhead, outside the boundaries of the populations proposed here for protection under CESA. While Klamath Mountain Province summer steelhead populations are not as low as Northern California summer steelhead

populations, Moyle et al assign the population precisely the same Status Score, 1.9 out of 5.0, as they do the Northern California summer steelhead. They note that "Klamath Mountain Province (KMP) summer steelhead are in a state of long-term decline in the basin. These stream-maturing fish face a high likelihood of extinction in California in the next fifty years."

Thus, KMP summer steelhead, like Northern California summer steelhead, are "in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease," and thus can and should be designated and protected as an endangered species under the California Endangered Species Act. (F&GC § 2062)

This presents the Commission and the Department with the question whether to protect only Northern California summer steelhead at this time, or to protect all summer steelhead in California together. We encourage the Department and the Commission to carefully consider all the relevant factors facing both KMP and Northern California summer steelhead in reaching a decision. It is clear that the scientific evidence would support a listing of "endangered" under CESA for either or both stocks.

(C) distribution;

NC summer steelhead are far from uniformly distributed even in their limited range.

NMFS' 2016 MSRP lays out recovery objectives for the existing NC steelhead DPS:

> *Ten independent summer-run steelhead populations expected to meet effective population size criteria ... (i.e., Redwood Creek, Mad River, South Fork Eel River, Mattole River, Van Duzen River, Larabee Creek, North Fork Eel River, Upper Middle Mainstem Eel River, Middle Fork Eel River, and Upper Mainstem Eel River). (p. 2)*

But only a few of watersheds have recent evidence of more than a dozen adult summer steelhead. The Middle Fork Eel, Van Duzen, and Mattole populations make this list; the Mad River probably does. The North Fork Eel and Upper Mainstem Eel almost certainly don't have NC summer steelhead at all. The Upper Mainstem Eel might provide habitat for an additional vitally important population if access to the habitat above Scott Dam could be restored to Northern California summer steelhead. Of course, with very low numbers of fish in a given watershed, it becomes increasingly difficult for the remaining fish to spawn successfully.

(E) life history;

Moyle et al summarize the NC summer steelhead's unique life history as follows:

> *Summer steelhead are stream-maturing ecotype fish that enter freshwater with undeveloped gonads, and then mature over several months in freshwater. This life history is uncommon compared to ocean-maturing or winter-run fish. These steelhead oversummer in typically deep, bedrock holding pools and remote canyon reaches of streams with some overhead cover and subsurface flow to keep cool until higher flows arrive in winter (Busby et al. 1996).*

> *NC summer steelhead enter estuaries and rivers as immature fish between April and June in the northern portion of the DPS (Redwood National Park 2001). In the Mad River, summer steelhead enter the mouth in early April through July as flows allow (M. Sparkman, CDFW, pers. comm. 2016). Mattole summer steelhead enter the river between March and June (Mattole Salmon Group 2016), and further migrations upstream occur from June on, but timing depends upon rainfall and consequent suitable stream discharge for passage into upper sections of watersheds. Spawning happens primarily in the winter between December and early April in headwater reaches of streams not utilized by winter steelhead (Roelofs 1983, Busby et al. 1997), though favorably wet conditions may lengthen the spawning period into May. Infrequent observations of steelhead spawning in June have also been reported on the Mattole River (Mattole Salmon Group 2016).*

The Northern California summer steelhead life history has important consequences for their conservation. As Moyle et al describe, NC summer steelhead are by definition unusual for the steelhead taxon. They occupy headwaters habitats right at the margin of salmonid tolerance in a range at the edge of salmonid tolerances. NC summer steelhead specialize in exploiting relatively limited dry-season holding habitats in order to make greater use of spawning and rearing habitats higher up in watersheds than winter-run steelhead. They play important ecological roles in areas no other anadromous salmonid reach. The summer steelhead life history makes these strategic choices to gain access to spawning habitats where it will not compete with winter run steelhead.

Northern California summer steelhead are inherently more subject to predation and disease in freshwater than their winter run counterparts. As adults and as juveniles, NC summer steelhead spend more time in freshwater. Both adults and juveniles face the poor water conditions, including low flow, high temperature, and high pollution levels, that summer and fall bring to the rivers they inhabit, limiting the mobility of over-summering fish within a watershed. Very low population numbers are especially vulnerable to predation impacts. Introduced pikeminnow are a major anthropogenic burden on juvenile steelhead, including summer steelhead, throughout much of the Eel River watershed. However, summer steelhead can easily pass barriers pikeminnow cannot, so they may be less subject to predation around spawning areas than winter run steelhead.

The NC summer steelhead life history also makes it more vulnerable to the impacts of climate change than winter run steelhead. NMFS acknowledges those stark differences in Appendix B of the MSRP, which analyzes the effects of climate change on Chinook salmon and steelhead recovery:

> *We did consider summer-run steelhead in the NC steelhead DPS somewhat separately. Because juvenile summer run steelhead emerge from redds in the winter, and then usually rear in streams for 1-3 years, they share similar vulnerabilities to climate change as juvenile winter-run steelhead (although in some cases they may be more susceptible to redd scour). However, because summer-run adults enter streams in late spring/early summer, and hold in mainstems until early fall to spawn, summer-run steelhead adults are likely more vulnerable to climate change impacts than winter-run adults in most (if not nearly all) cases*. (NMFS 2016, Appendix B, pg. 19).

Finally, and critically, a recent paper has demonstrated that the premature migration observed in both summer steelhead and spring Chinook arises from a mutation at a specific area in the salmonid genome. (Prince et al 2017) The Prince et al analysis is critically relevant to the question of Northern California summer steelhead conservation policy for at least two reasons. It shows that summer steelhead are genetically distinct in profound ways from winter steelhead in the same watersheds.

As well, it shows that the assumption underlying the current combined listing of winter and summer steelhead as DPS under the federal Endangered Species Act – that if lost, summer steelhead can re-emerge from winter steelhead populations – is without foundation. Rather, the study shows that a unique evolutionary event was the cause for the spatial and temporal reproductive isolation that summer and winter-run steelhead exhibit in the coastal rivers of Northern California. Because summer steelhead arose from a unique evolutionary event, they are unlikely to re-evolve over ecological time scales. (Prince et al 2017).

This new genetic explanation adds to the existing evidence that NC summer steelhead are different from winter run steelhead in a number of ways that merit the close attention of the Commission in determining what level of protection Northern California summer steelhead should receive. Moyle et al explain that:

> *the two runs are distinctive in their genetic makeup, behavior, and reproductive biology... Genetic analyses support two discrete, separate monophyletic units of migrating populations based primarily on timing of freshwater entry and resulting maturation (Papa et al. 2007), correlating with run timing for the ocean-maturing (winter) and stream-maturing (summer, fall) ecotypes (Prince et al. 2015).* (Moyle 2017, pp. 270-71)

(F) kind of habitat necessary for survival;

Moyle et al summarize NC summer steelhead habitat requirements by life stage, p. 273:

> *Steelhead require distinct habitats for each stage of life. The abundance of summer steelhead in a particular location is influenced by the quantity and quality of suitable coldwater habitat during low flow summer and fall months, food availability, and interactions with other species. Over-summering habitat for adult summer steelhead is critical for survival of this life history. In general, suitable habitats are often distributed farther inland than those for winter steelhead in the same watersheds (Moyle 2002).*
>
> *Adult steelhead have a body form adapted for holding in faster water than most other salmonids with which they co-occur can tolerate. Within California, Bajjaliya et al. (2014) found important differences in steelhead morphology based on flow regimes and habitats occupied. Northern California steelhead had the largest individuals, on average, than populations of steelhead from elsewhere in the state. In general, coastal steelhead that occupied smaller, slower coastal rivers were deeper bodied, longer, and more robust than steelhead from larger inland rivers with higher velocities. Low flows associated with more inland rivers and tributaries do not facilitate passage of larger bodied adults, and therefore select for smaller, more streamlined fish. Adult summer*

steelhead require water depths of at least 18 cm for passage (Bjorn and Reiser 1991), however, this may not take into account the deep-bodied, robust physiology of coastal steelhead in the NC steelhead DPS, which would require slightly more flow to allow passage (Bajjaliya et al. 2014). Reiser and Peacock (1985 in Spence et al. 1996) reported the maximum leaping ability of adult steelhead to be 3.4 m. Hawkins and Quinn (1996) found that the critical swimming velocity for juvenile steelhead was 7.7 body lengths/sec compared to juvenile cutthroat trout that moved between 5.6 and 6.7 body lengths/sec. Adult steelhead swimming ability is hindered at water velocities above 3 m/sec (Reiser and Bjornn 1979). Preferred holding velocities are much slower, and range from 0.19 m/sec for juveniles and 0.28 m/sec for adults (Moyle and Baltz 1985). Physical structures such as boulders, large woody debris, and undercut banks create hydraulic heterogeneity that increases availability of preferred habitat in the form of cover from predators, visual separation of juvenile territories, and refuge during high flows.

Steelhead require cool water and holding habitat to withstand the higher temperatures and lower flows of summer and fall while they mature. Important factors influencing summer steelhead habitat use are pool size, low substrate embeddedness (< 35%), presence of riparian habitat shading, and instream cover associated with increased velocity through the occupied pools (Nakamoto 1994, Baigun 2003). Temperatures of 23-24°C can be lethal for the adults (Moyle 2002), which can limit abundance and spatial distribution. Subsurface, or hyporheic, flows can be important to providing cool, flowing water in habitats separated by thermal or other barriers. In August 2015 on the upper Middle Fork Eel River, adult summer steelhead were observed in pools of varying depth, but only with maximum temperatures of less than 23°C.

For spawning, adult steelhead require loose gravels at pool tails for optimal conditions for redd construction. Redds are usually built in water depths of 0.1 to 1.5 m where velocities are between 0.2 and 1.6 m/sec. Steelhead use a smaller substrate size than most other coastal California salmonids (0.6 to 12.7 cm diameter). Spawning habitat for summer steelhead can be variable, but their temporal and spatial isolation from other steelhead runs maintain low levels of genetic differentiation from winter steelhead in the same watershed (Barnhart 1986, Papa 2007, Prince et al. 2015). Summer steelhead can spawn in intermittent streams, from which the juveniles emigrate into perennial streams soon after hatching (Everest 1973). Roelofs (1983) suggested that use of small streams for spawning may reduce egg and juvenile mortality because embryos may be less susceptible to scouring by high flows and predation on juveniles by adults.

After spawning, adult steelhead, called "kelts" at this life stage, are capable of rapidly making their way back out to sea; the entire migration and spawning cycle of an adult fish can be completed in less than ten days (J. Fuller, NMFS, pers. comm. 2016). In contrast, in Redwood Creek, relatively large numbers of kelts migrate downstream through the lower watershed in March (M. Sparkman, CDFW, pers. comm. 2016). Due to the relatively short distances these fish must travel in small coastal watersheds to

spawn, their survival rates and incidence of repeat spawning are higher than steelhead in the much larger Eel River, which reach dozens of kilometers inland.

Embryos incubate for 18 to 80 days, depending on water temperatures, which are optimal in the range of 5 to 13° C. Hatchery steelhead take 30 days to hatch at 11°C (Leitritz and Lewis, 1980 in McEwan and Jackson, 1996), and emergence from the gravel occurs after two to six weeks (Moyle 2002; McEwan and Jackson 1996). High levels of sedimentation (> 5% sand and silt) can reduce redd survival and emergence due to decreased permeability of the substrate and dissolved oxygen concentrations available for the incubating eggs (McEwan and Jackson 1996). When fine sediments (< 2.0 mm) compose > 26% of the total volume of substrate, poor embryo survival is observed (Barnhart 1986). Emerging fry can survive at a greater range of temperatures than embryos, but they have difficulty obtaining oxygen from the water at temperatures above 21.1°C (McEwan and Jackson 1996).

During the first couple years of freshwater residence, steelhead fry and parr require cool, clear, fast-flowing water (Moyle 2002). Exposure to higher temperatures increases the energetic costs of living for steelhead and can lead to reduced growth and increased mortality. As temperatures become stressful, juvenile steelhead will move into faster riffles to feed on more abundant prey (Moyle 2002 and bioenergetic box in SONCC coho account) and seek out cool- water refuges associated with cold-water tributary confluences and gravel seeps. In Redwood Creek, young-of-year (YOY) steelhead may travel 46 km downstream during summer months in search of rearing areas (M. Sparkman, CDFW, pers. comm. 2016). In the Mattole River, juvenile steelhead are found over-summering throughout the basin, although water temperatures often restrict their presence in the estuary. Cool water areas, including some restoration sites, provide refuge from temperatures that can rise above 19°C in the Mattole (Mattole Salmon Group 2005). However, juvenile steelhead can live in streams that regularly exceed 24°C for a few hours each day with high food availability and temperatures that drop to more favorable levels at night (Moyle 2002, M. Sparkman, CDFW, pers. comm. 2016).

Many of these habitats are vulnerable to a range of anthropogenic impacts. Such impacts have seriously degraded the capacity of the NC summer steelhead range to support the population over the last century and a half. This historic and continuing degradation of habitat is why many of the watersheds that did once support significant populations of Northern California summer steelhead now have only a few, or no, returning adults.

Moyle et al summarize 15 major anthropogenic factors limiting viability of Northern California summer steelhead populations, and rated them on their potential to impact the species. Three factors were ranked as "High," meaning they could push a species to extinction in 10 generations or 50 years: Major dams, on the Eel and Mad Rivers[1]; agriculture, including impacts from conventional agriculture in lower watersheds and diversions and pollution associated with unpermitted marijuana cultivation; and estuarine

[1] Note that NMFS disputes Moyle et al's characterization of the impact of Ruth Dam on potential NC summer steelhead habitat in the Mad River.

alteration, again especially in the Eel and the Mad Rivers. (p. 285) An additional five factors were ranked as "Medium," i.e., unlikely to drive a species to extinction by itself but contributing to increased extinction risk; they include grazing, rural/ residential development, transportation, logging, and hatcheries.

To these already severe threats, we now must add the very significant impacts of climate change on Northern California summer steelhead and the key habitats the species requires. Moyle et al emphasize the severity of these threats at pages 286-87:

> *Climate change is a major threat to the continued persistence of NC summer steelhead. In general, climate change will impact the freshwater habitat of steelhead in several important ways:*
>
> *1. Increased runoff and flooding, scouring redds*
>
> *2. Higher stream temperatures reducing habitat quality and survival*
>
> *3. Lower stream flows reducing habitat quantity and accessibility*
>
> *4. Earlier spring snowmelt reducing juvenile outmigration success*
>
> *5. Altered ocean circulation and productivity reducing sub-adult growth and survival in the marine environment (decrease in smolt to adult survival)*
>
> *6. Higher stream temperatures and flows creating thermal and velocity migration barriers to juveniles and adults in both marine and freshwater*
>
> *7. Increased frequency and intensity of catastrophic wildfires, threatening salmonid survival with attendant erosion, mass wasting,etc.*
>
> *8. Altered woody debris availability and characteristics reducing holding areas for juvenile salmonids*
>
> *9. Higher temperatures shifting range of suitable habitat northward in ocean and freshwater habitats*
>
> *10. Increased eutrophication of estuaries that serve as important nurseries and foraging habitat for juvenile and sub-adult salmonids*
>
> *To summarize the recent NMFS findings on climate-related impacts to NC steelhead, the primary concerns focus on altered streamflows and warmer temperatures, which reduce survival and passage through reductions in suitable holding, spawning, and rearing habitat. These impacts can reduce life history diversity, further stressing low populations of summer steelhead (NMFS 2016). NMFS considered summer-run steelhead in the DPS separately from winter-run fish, due to their increased susceptibility to redd scour due to timing of spawning and necessary holding in mainstem rivers during the warmest months of the year (NMFS 2016). Summer steelhead were found to be more vulnerable to these impacts than winter fish in "most (if not nearly all) cases" (NMFS 2016, Appendix B, pg. 21). Using a threat vulnerability analysis, NOAA Fisheries forecast that NC summer steelhead populations in the Redwood Creek, Van Duzen River, North and South Fork Eel, and Mattole are all highly susceptible to climate change impacts in the near future (NMFS 2016). These impacts*

are already being seen throughout the DPS range, and are limiting suitable upper watershed habitat for summer steelhead. Persistence of these populations is likely only with increased protection and restoration to improve stream flows, allow accessibility to prime holding and spawning habitat, and maintain cool temperatures in headwater tributaries for both spring Chinook salmon and summer steelhead.

Modeling of high greenhouse gas emissions scenarios have forecast increasing frequency and duration of critical drought, which exacerbates and compounds these impacts by reducing overall streamflow and increasing the variability in timing of precipitation events in California (NMFS 2016). As a result, Northern California summer steelhead may experience local extinctions and range contractions since higher gradient or elevation headwater streams are inaccessible behind falls, boulder fields, or dams in the DPS. Ongoing drought in California has likely contributed to a dip in populations of summer steelhead in the DPS, as lower flows and warmer summer water temperatures likely caused increased mortality before spawning. Persistent drought is likely to exacerbate already acute problems associated with depletion of summer baseflows, reduction of coldwater refugia, or even stream dewatering during the late summer and early fall months by reducing spawning, rearing, and migration habitat. More frequent and severe droughts are likely to contribute to higher occurrences of low summer baseflows that fuel toxic cyanobacteria blooms and degrade food webs that oversummering adult steelhead and juveniles depend on (Power et al. 2015). If summer temperatures increase during summer and early fall month and precipitation and prevalence of fog decrease, as has been observed in Northern California over the last fifty years, stream temperatures will rise and further stress summer-rearing salmonids and summer steelhead holding in pools (Madej 2011).

Drought and poor ocean conditions tied to climate change and El Nino conditions likely caused some decline in salmonid populations across the state by reducing coldwater upwelling and food availability (Daly et al. 2013, Williams et al. 2016). Changes in precipitation patterns could lead to flooding, contributing sediments from highly erodible terrain that smothers valuable gravel and fills in pool habitat. As populations continue to decline and become more fragmented, stochastic events such as increased catastrophic fire may change genetic structure, breeding, and population dynamics in ways that are unrecoverable.

Northern California summer steelhead are fantastically well-adapted to specific habitats that the coastal watersheds of Northern California have generally provided for millenia. Human activity has disrupted most of this habitat, even in the relatively undeveloped mountains of northwestern California. Anthropogenic climate change renders more habitat inhospitable. The combination of these impacts threatens Northern California summer steelhead with extinction in the near future.

(G) factors affecting the ability to survive and reproduce;

To a great extent, the critical factors affecting the ability of Northern California summer steelhead to survive and reproduce are the habitat issues discussed in section **(F)** immediately above. For adults, cool water and holding habitat; for reproduction, spawning

and rearing habitat are all essential to maintaining and recovering NC summer steelhead populations. Of course, as anadromous fish, the questions of ocean conditions present another complex of factors that will affect survival and successful reproduction.

(H) degree and immediacy of threat;

As noted, Moyle et al assess the status of Northern California summer steelhead as Critical, reflecting further decline from a 2008 review that found the species already at a High level of risk:

> *NC summer steelhead have a high risk of extinction in the next 50 years without significant restoration and intervention. ... This status could deteriorate rapidly if restoration and protection efforts are not put into effect.* (Moyle 2017, pp. 287)

With only a relative few, relatively small populations remaining, NC summer steelhead are subject to rapid, likely irrecoverable loss from stochastic events or human action.

(I) impact of existing management efforts;

Despite the clear threats to NC summer steelhead, they are not listed under the California Endangered Species Act. Moyle et al explicitly argue that they should be so listed:

> *NC summer steelhead currently have no special conservation status within the state of California, but should be officially recognized as threatened under the California Endangered Species Act by the Fish and Game Commission or at least declared a state Species of Special Concern.* (Moyle 2017, pp. 287)

The absence of state protections for NC summer steelhead reduces the ability of DFW to prioritize reducing impacts on key populations and promoting and coordinating actions necessary to recover the species.

Many state and federal agency efforts are devoted to protecting Northern California summer steelhead and NC steelhead generally. However, as Moyle et al summarize, existing state and federal programs have so far proved inadequate to protect Northern California summer steelhead and its habitat:

> *Northern California summer steelhead are trending downward over time, and require significant action to recover from legacy impacts of road building, logging, forest fires, poor water quality, and disjointed land use throughout their range. Increasing rural development and illegal diversions and withdrawals for illegal marijuana cultivation throughout the DPS range, coupled with five years of ongoing historic drought, have significantly stressed summer steelhead populations and have driven their decline. Other threats across diversity strata include dearth of large woody debris and cover for rearing fish, abundance of roads and railroads adjacent to sensitive watersheds and associated sedimentation/erosion, illegal diversion and degradation, presence of barriers to migration, and lack of sufficient high quality spawning and rearing habitat due to uncoordinated land use practices (NMFS 2016).*
>
> *To ameliorate these threats, the NMFS Coastal Multispecies Recovery Plan for the NC steelhead DPS lays out a full suite of necessary recovery actions and essential partners (NMFS 2016). CDFW is currently revising a steelhead restoration and management*

plan, which will help compile threats and identify specific actions to restore and manage steelhead in California (Nelson 2016). However, lack of coordination and prioritization of specific actions to protect summer-run life history steelhead in California represents a major challenge. Although designation of ESUs and DPSs are based upon distinctiveness of life-history traits and distinguishing genetic characteristics, such distinctions are not guiding conservation of steelhead life history diversity at the watershed scale, which is essential for maintaining populations of summer steelhead in the future.

As Moyle et al highlight in the above excerpt, the designation of Northern California summer steelhead as part of a NC steelhead DPS dominated by winter run steelhead has itself become an obstacle to effective conservation of Northern California summer steelhead. In view of the best available scientific information, this framework appears not only inadequate to insure the recovery of NC summer steelhead, but likely to lead to the extinction of summer steelhead in the region.

In its most recent status review for the NC steelhead DPS, NMFS concluded that while winter-run steelhead populations are relatively healthy, and the DPS as a whole does not appear, in the agency's opinion, to face an increased risk of extinction, "(s)ummer-run populations continue to be of significant concern. While one run is near the viability target, others are very small or there is a lack of data." (NMFS 2016 Five Year Status Review p. 41) Indeed, as Prince et al note, "despite the extirpation or substantial decline of premature migrating populations, the ESUs or DPSs to which they belong usually retain relatively healthy mature migrating populations and thus have low extinction risk overall." (p. 2)

As Prince et al imply, summer steelhead face extinction in part due to an error of classification that improved genetic analysis now allows us to correct. A conservation strategy that fails to effectively conserve summer steelhead – as the current strategy of considering them part of a larger DPS of *O. mykiss* dominated by winter-run steelhead in the same watersheds is failing – is likely actually to lead to the extinction of these unique forms of summer steelhead.

Northern California summer steelhead should be listed and protected under CESA separately from NC winter steelhead.

(J) suggestions for future management;

As Moyle et al note in the excerpt cited under (I) above, both NMFS and DFW have prepared or are in the process of preparing extensive and detailed prescriptions for management actions necessary to protect Northern California summer steelhead and its various habitats. Those menus of potential actions do little in the absence of the institutional resources and political will to actually undertake a comprehensive effort. As Moyle et al emphasize, "lack of coordination and prioritization of specific actions to protect summer-run life history steelhead in California represents a major challenge."

The most significant step the Commission can take to increase the prioritization and effective coordination of actions necessary to protect Northern California summer steelhead is to list the species as endangered under CESA.

(K) availability and sources of information

Of course, the California Department of Fish and Wildlife is the expert agency with responsibility for Northern California summer steelhead. DFW generated much of the information that is the subject of the studies and analyses discussed here.

The sources cited in this petition are likely to prove critical sources of information about Northern California summer steelhead, their habitat, threats to the species, and the best available science concerning the species and their conservation.

These include the comprehensive overview of salmonids in California, *State of the Salmonids: Status of California's Emblematic Fishes 2017* , which we have referred to as Moyle et al 2017. As well, NMFS has prepared status reviews for NC steelhead every five years since the DPS was listed as threatened. The MRPS noted above is essential. Finally, two papers, Prince et al 2017 and Thompson et al 2018, provide important perspective on the genetic basis of premature migration in salmonids and the need to protecting the genetic and behavioral diversity Northern California summer steelhead embody.

CESA Listing Factors

CESA commands that "(a) species shall be listed as endangered or threatened, as defined in sections 2062 and 2067 of the Fish and Game Code, if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors." CEQA specifically commands the Commission to consider five types of impacts on the species in deciding whether to list a species under CESA.

1. Present or threatened modification or destruction of its habitat

As noted above, habitat modification, destruction, and degradation from a range of human impacts is the key driver of Northern California summer steelhead decline across its range. Climate change is now amplifying the impacts of other anthropogenic factors, and threatens to render much of Northern California summer steelhead habitat unsuitable for the species in the relatively near future.

2. Overexploitation

Overfishing, both commercial and recreational, played important roles in the dramatic reduction of Northern California summer steelhead populations during the 20th Century, but there is little evidence that it is now a significant threat to Northern California summer steelhead. There are some continuing impacts associated with the recreational fishery, especially during the recent historic drought.

However, poaching remains a significant threat to Northern California summer steelhead today. The NMFS MSRP states:

> *The problem with poaching continues to plague summer steelhead due to the absence of adequate law enforcement (Moyle et al. 2008). Although fishing is prohibited in many areas and fines for violations are high, protection of summer steelhead populations requires special enforcement efforts (Moyle et al. 2008).* p. 10

3. Predation

As noted above, the Northern California summer steelhead life history renders the species significantly more vulnerable to predation than winter run steelhead as both juveniles and as adults. With very small populations in some NC summer steelhead watersheds, there is an increased risk that predation could eliminate spawning opportunities.

The introduction of pikeminnow to Northern California summer steelhead habitat in the Eel River watershed has significantly increased the impact of predation on Northern California summer steelhead. While pikeminnow are native to California, and even to the Russian River immediately to the south, they are not native to the Eel River. NMFS acknowledge the threat in the most recent status review for Northern California summer steelhead: "Introduced Sacramento pikeminnow is a serious predator limiting salmonid recovery (Yoshiyama and Moyle, 2010). Their populations have flourished with warmer water conditions, and they consume juvenile salmonids throughout the Eel River Basin." (NMFS 2016, p. 35.)

4. Competition

It is not clear that competition is a significant factor driving the decline of Northern California summer steelhead.

5. Disease

As noted above, both the Northern California summer steelhead life history and climate-change related impacts expose Northern California summer steelhead to additional disease threats beyond those faced by winter run steelhead. Disease threats can emerge very rapidly, confounding response efforts that have not been carefully pre-planned.

6. Other natural occurrences or human-related activities

As noted above, climate change presents an overarching and severe threat to Northern California summer steelhead across its remaining range.

As well, it is worth emphasizing that the construction of Scott Dam (1922) eliminated significant portions of historic spawning habitat for steelhead in the Upper Mainstem Eel River including "*some of the best spawning grounds in the entire watershed (Gravelly Valley)* (Shapovalov 1939)." (MSRP p. 98) Cooper estimated more than two hundred miles of potential NC steelhead spawning and rearing habitat in the Upper Mainstem Eel River basin above the dam. (Cooper 2017) If passage past Scott Dam is not provided, it will not be even theoretically possible to achieve the recovery goals set by NMFS for Northern California summer steelhead recovery in its MSRP.

Conclusion

In summary, Northern California summer steelhead are a unique and extraordinary form of steelhead, whose exquisite adaptation to their extreme environmental niches is determined by a critical and highly specific genetic difference from winter run steelhead. Northern California summer steelhead are not being effectively conserved by being managed as part of a larger population of more numerous and less vulnerable winter run steelhead. In fact, Northern California summer steelhead face imminent extirpation in

many of the watersheds where they still survive. If NC summer steelhead are lost, the genetic basis of their remarkable life history is likely to be lost as well.

Given these facts, protection under CESA is both warranted and necessary to ensure that California's future citizens may continue to enjoy these irreplaceable fish and the contribution they make to our magnificent Northern California ecosystems.

Thank you for your kind attention to these important questions.

Very truly yours,

Scott Greacen
Conservation Director
Friends of the Eel River

REFERENCES

Abadia-Cardoso, A. 2014. "Genetic investigation of the Pacific trout complex: from pedigrees to phylogenies." *Ph.D. dissertation*. University of California, Santa Cruz.

Abadia-Cardoso, A. et al. 2015. "Genetic structure of Pacific trout at the extreme southern end of their native range and patterns of introgression from hatchery rainbow trout." *PLoS ONE* 10: 30141775.

Abadia-Cardoso, A. et al. 2016. "Population Genetic Structure and Ancestry of Steelhead/Rainbow Trout (*Oncorhynchus mykiss*) at the Extreme Southern Edge of their Range in North America." *Conservation Genetics*. DOI 10.1007/s10592-016-0814-9.

Adams, P., et al. 2011. "California Coastal Salmonid Population Monitoring: Strategy, Design, and Methods." *Fish Bulletin 180*. Prepared for State of California; Department of Fish and Game. 82 pp.

Aguilar, A. and J. C. Garza. 2006. A comparison of variability and population structure for major histocompatibility complex and microsatellite loci in California coastal steelhead (*Oncorhynchus mykiss* Walbaum). *Molecular Ecology*, 15, 923- 937.

Anderson, D. 1961. "Status of Summer Steelhead Trout in Redwood Creek, Redwood National Park, California." *National Parks Transactions and Proceedings* (9): 2-8.

Araki, H., Cooper, B. and M. Blouin. 2007. "Genetic effects of captive breeding cause a rapid cumulative fitness decline in the wild." *Science*, 381, 100-103.

Araki, H., Cooper, B., and M. Blouin. 2009. "Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild." *The Royal Society Biology Letters* (5): 621–624.

Armour, C., D. Duff, and W. Elmore. 1994. "The effects of livestock grazing on western riparian and stream ecosystems." *Fisheries* 19(9):9-12.

Arriaza, J. 2015. "Unraveling Steelhead Life-History Complexity through Mathematical Modeling." Chapter 2: The Roles of Rearing and Rescue in Maintaining the Anadromous Life- History, with Application to Steelhead in the Carmel River. Ph.D. Dissertation. University of California, Santa Cruz, Santa Cruz, CA. UC Santa Cruz Electronic Theses and Dissertations. Web: http://escholarship.org/uc/item/6wr126tk.

Augerot, X. and D. Foley. 2005. *Atlas of Pacific Salmon*. University of California Press. Berkeley, CA.

Bagley, M. 1997. "Molecular genetic analysis of rainbow trout populations." PhD Dissertation. University of California. Davis, CA.

Bagley, M. and G. Gall. 1998. Mitochondrial and nuclear DNA sequence variability among populations of rainbow trout (*Oncorhynchus mykiss*). *Molecular Ecology*, 7, 945-961.

Bagley, M., A. Gall, and B. May. 1998. "Genetic analysis of 1997 trout collections." Report to the Threatened Trout Committee, California Department of Fish and Wildlife. Genomic Variation Laboratory, University of California, Davis. 15 pp., plus appendices.

Baigun, C. 2003. "Characteristics of deep pools used by adult summer steelhead in Steamboat Creek, Oregon." *North American Journal of Fisheries Management*, 23, 1167-1174.

Baker, P. and J. Morhardt. 2001. "Survival of Chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean." Pages 163-196 in R. L. Brown, (ed.). *Contributions to the biology of Central Valley salmonids*. California Department of Fish and Game Fish Bulletin 179.

Barnhardt, R. 1986. "Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - Steelhead." U.S. Fish and Wildlife Service. Biological Report 82 (11.60). U.S. Army Corps of Engineers, TR EL-82-4. 21 pp.

Barnhardt, R. 1994. "Salmon and steelhead population of the Klamath-Trinity basin, California." in Hassler, T. (Ed.) *Klamath Basin Fisheries Symposium: Proceeding of a symposium*. Arcata CA, California Cooperative Fishery Research Unit, Humboldt State University.

Barth, J. et al. 2007. "Delayed upwelling alters near shore coastal ocean ecosystems in the northern California Current Proceedings." *National Academy of Sciences*, 104, 3719-3724.

Bauer S, et al. 2015. "Impacts of Surface Water Diversions for Marijuana Cultivation on Aquatic Habitat in Four Northwestern California Watersheds." *PLoS One*. 10(3): e0120016.

Beakes, M. et al. 2010. "Smolt transformation in two California steelhead populations: effects of temporal variability in growth." *Transactions of the American Fisheries Society.* 139:1263–1275.

Becker, G. and I. Reining. 2008. "Steelhead/rainbow trout resources south of the Golden Gate, California." Oakland CA: Center for Ecosystem Management and Restoration. 425 pp.

Beechie et al. 2015. "Comparison of Potential Increases in Juvenile Salmonid Rearing Habitat Capacity among Alternative Restoration Scenarios, Trinity River, California." *Restoration Ecology.* 23(1): 75–84.

Behnke R. 1992. *Native trout of western North America*. American Fisheries Society, Bethesda.

Behnke, R. 2002. *Trout and salmon of North America.* New York, Simon and Schuster Press.

Behnke, R. and M. Zarn. 1976. "Biology and management of threatened and endangered western trout." U.S. Forest Service General technical Report RM-28. Rocky Mountain Forest Range Experiment Station, Fort Collins, Co. 45 pp.

Belchik, M. 1997. "Summer locations and salmonid use of cool water areas in the Klamath River, Iron Gate Dam to Seiad Creek, 1996." Yurok Tribal Fisheries Program, Klamath, CA.

Bell, E. 2016. "Assessing Instream Needs for Steelhead in Coastal California." Stillwater Sciences. Presentation to the Second Steelhead Summit, Oct. 27-28, San Luis Obispo, CA. Web: https://www.calsalmon.org/sites/default/files/files/2016_SH_Summit_Instream_Flow_Presentati ons_1.pdf.

Bell, E., Albers, S. and R. Dagit. 2011. "Juvenile growth in a population of southern California steelhead (*Oncorhynchus mykiss*)." *California Department of Fish and Game* 97: 25-35.

Bell, E., Dagit, R. and F. Ligon. 2012. "Colonization and Persistence of California Steelhead (*Oncorhynchus mykiss*) Population." *Bulletin of the Southern California Academy of Sciences* 110: 1-16.

Berg, B. 1987. "Evolutionary genetics of rainbow trout, (*Parasalmo gairdneri*) (Richardson)." Unpublished PhD dissertation, U.C. Davis. 184 pp.

Berg, W. and G. Gall. 1998. "Gene flow and genetic differentiation among California coastal rainbow trout populations." *Canadian Journal of Fisheries and Aquatic Science*, 45, 122-132.

Bisson, P. et al. 1982. "A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow." Pages 62-72. In N. B. Arman (ed.), *Acquisition and utilization of aquatic habitat inventory information*. Proceedings of the Symposium of the American Fisheries Society, Western Division.

Bjorkstedt, E. 2005. "An analysis of historical population structure for Evolutionarily Significant Units of Chinook salmon, coho salmon, and steelhead in the North-Central California Coast Recovery Domain." NOAA-TM-NMFS-SWFSC-382. NOAA-National Marine Fisheries Service.

Bjornn, T. and D. Reiser. 1991. "Habitat requirements of salmonids in streams." Pages 83-138 In W. R. Meehan, ed. *Influences of forest and rangeland management on salmonid fishes and their habitats*. American Fisheries Society Special Publication 19. Bethesda, Maryland.

Bjornn, T. and D. Reiser. 1991. "Habitat requirements of salmonids in streams." *American Fisheries Society Special*

Publication 19:83-138.

Bond, M. 2006. "Importance of estuarine rearing to Central California steelhead (*Oncorhynchus mykiss*) growth and marine survival." Master's Thesis. University of California, Santa Cruz. Santa Cruz, CA. 68 pp.

Bond, M. et al. 2008. "Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary." *Canadian Journal of Fisheries and Aquatic Sciences* 65:2242–2252.

Borok, S. and H. Jong. 1997. "Evaluation of salmon and steelhead spawning habitat quality in the South Fork Trinity River basin, 1997." Inland Fisheries Administrative Report No. 97-8.

Boughton, D. 2016. "Conditional Smolting and the Response of Carmel River Steelhead to Two Decades of Conservation Efforts." NOAA SWFSC. Presentation to the Second Steelhead Summit, Oct. 27-28, San Luis Obispo, CA. Web: http://calsalmon.org/sites/default/files/files/2016_SH_Summit_Coastal_Monitoring_Presentation s.pdf.

Boughton, D. et al. 2005. "Contraction of the southern range limit for anadromous *Oncorhynchus mykiss*." NOAA-TM-NMFS-SWFSC-380.

Boughton, D. et al. 2006. "Steelhead of the South-Central/Southern California Coast: Population characterization for recovery planning NMFS- Southwest Fisheries Science Center."

Boughton, D. et al. 2007a. "Stream temperature and the potential growth and survival of juvenile *Oncorhynchus mykiss* in a southern California creeks." *Freshwater Biology*, 52, 1353-1364.

Boughton, D. et al. 2007b. "Viability Criteria for Steelhead of the South-Central and Southern California Coast." NOAA Technical Memorandum NMFS-SWFSC-407. 47pp.

Boughton, D. et al. 2009. "Spatial patterning of habitat for *Oncorhynchus mykiss* in a system of intermittent and perennial streams." *Ecology of Freshwater Fishes.* 18:92-105.

Boughton, D. et al. 2015. "Terminal Potential for Steelhead Life History Expression in a Southern California Alluvial River." *Transactions of the American Fisheries Society*. 144:258- 273.

Boughton, D. et al. 2016. "South-Central/Southern California Coast Recovery Domain – Summary and Evaluation of South-Central California Coast Steelhead Distinct Population Segment" Pages 64-80 in Williams, T. et al. 2016. *Viability Assessment for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest*. 2016 Report to National Marine Fisheries Service – Southwest Fisheries Science Center, Fisheries Ecology Division. 197pp. Web: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/201 6_sccc-steelhead.pdf.

Boughton, D. et al. 2017. "Spatial Structure of Water-Quality Impacts and Foraging Opportunities for Steelhead in the Russian River Estuary: An Energetics Perspective." NOAA- TM-NMFS-SWFSC-569. 42pp.

Boughton, D. Unpublished data. "The boundary area between central coast and south-central coast steelhead ESUs in California: zoogeography and ecology." NMFS Southwest Fisheries Science Center report. 12pp.

Bovee, K. 1978. "Probability-of-use criteria for the family *Salmonidae*." Instream flow information paper 4. US Fish and Wildlife Service, FWS/OBS–78/07. 79 p.

Bowerman, T., Keefer, M. and C. Caudill. 2016. "Pacific Salmon Prespawn Mortality: Patterns, Methods, and Study Design Considerations." *Fisheries* 41(12): 738-749.

Brakensiek, K. and D. Hankin. 2007. "Estimating overwinter survival of juvenile coho salmon in a northern California stream: accounting for effects of passive integrated transponder tagging mortality and size-dependent survival." *Transactions of the American Fisheries Society*, *136*(5): 1423–1437.

Brenkman, S., Corbett, S., and E. Volk. 2007. "Use of Otolith Chemistry and Radiotelemetry to Determine Age-Specific Migratory Patterns of Anadromous Bull Trout in the Hoh River, Washington." *Transactions of the American Fisheries*

Society 136(1): 1-11.

Brinkman, S., Crockett, J. and Rogers, K. 2013. "Upper Thermal Tolerance of Mountain Whitefish Eggs and Fry." *Transactions of the American Fisheries Society*, 142:3, 824-831.

Brodeur, R. 2004. "Juvenile salmon distribution, growth, condition, origin, and environmental and species associations in the Northern California Current." *Fisheries Bulletin*, 102, 25-46.

Brown, D. et al. 2001. "Catastrophic wildfire and number of populations as factors influencing risk of extinction for Gila Trout (*Oncorhynchus gilae*)." *Western North American Naturalist* 61(2):139–148.

Brown, L. and P. Moyle. 1991. "Changes in habitat and microhabitat partitioning within an assemblage of steam fishes in response to predation by Sacramento squawfish (*Ptychocheilus grandis*)." *Canadian Journal of Fisheries and Aquatic Science*, 43, 849-856.

Brown, L. and P. Moyle. 1997. "Invading species in the Eel River, California: successes, failures, and relationship with resident species." *Environmental Biology of Fishes*, 48, 271-291.

Brown, R. 2005. "Understanding Central Valley Chinook and Steelhead: It's time to get on the dime." Editorial. *San Francisco Estuary and Watershed Science*.

Buchanan, D. et al. 1989. "Native Trout Project." Oregon Department of Fish and Wildlife Native Trout Project F-136-R. Annual Progress Report, 22 pp.

Buehrens et al. 2013. "Spatial Segregation of Spawning Habitat Limits Hybridization between Sympatric Native Steelhead and Coastal Cutthroat Trout." *Transactions of the American Fisheries Society* 142: 221-233.

Burns, J. 1972. "Some effects of logging and associated road construction on Northern California Streams." *Transactions of the American Fisheries Society*, 101.

Busby, P. et al. 1996. "Status Review of west coast steelhead from Washington, Idaho, Oregon, and California." U.S. Department of Commerce, NOAA. NMFS-NWFSC-27. 261 pp.

Busby, P., Wainwright, T., and R. Waples. 1994. "Status Review for Klamath Mountains Province Steelhead." Department of Commerce- NOAA. NMFS-NWFSC-19.

Bush, R. 2011. "Southern California Steelhead Spawning Observations in Two Dammed Rivers (Ventura and Malibu Creek)." Abstract. American Fisheries Society 141st Annual Meeting, September 4-8, 2011, Seattle, Washington.

CACSST. 1988. "Restoring the Balance." 1988 Annual Report. California Advisory Committee on Salmon and Steelhead Trout. Sausalito, California.

CALFED. 2005. "Bulletin 250: Fish Passage Improvement - A multi-agency report on the status of migration barriers to *Oncorhynchus* species of the Central Valley of California."

CalFish. 2017. "Central Valley Juvenile Salmon and Steelhead Monitoring. A California Cooperative Anadromous Fish and Habitat Data Program." Web: http://www.calfish.org/ProgramsData/ConservationandManagement/CentralValleyJuvenileSalmonandSteelheadMonitoring.aspx.

California Commissioners of Fisheries (CCF). 1881. "Report of the Commissioners of Fisheries of the State of California for the Year 1880." California Commissioners of Fisheries. Sacramento.

California Department of Fish and Game (CDFG). 1965. "California Fish and Wildlife Plan." State of California, California Department of Fish and Game. Vol. 1-3B.

California Department of Fish and Game. 1983. "1983 Summer Steelhead Survey, Middle Fork Eel River, Mendocino and

Trinity Counties." Report by E. Strecker.

California Department of Fish and Game. 1992. "Historical Distribution and Recent Trends of Summer Steelhead, *Oncorhynchus mykiss* in the Eel River, California." Report by W. E. Jones.

California Department of Fish and Game. 2014. "A Synopsis of Recent History of California's Inland Trout Management Programs: Litigation and Legislation." *California Fish and Game* 100(4): 727-739.

California Department of Water Resources (DWR). 2005. "Fish passage improvement 2005." Water Resources Bulletin 250. California Department of Water Resources.

CalFish. 2017. "Salmon Strongholds." Prepared for the California Department of Fish and Game by the Wild Salmon Center on behalf of the California Stronghold Team. 87pp.
http://www.calfish.org/FisheriesManagement/SalmonStrongholds.aspx.

California Hatchery Scientific Review Group (CHSRG). 2012. "California Hatchery Review: Statewide Report." Web: http://cahatcheryreview.com/hatchery-review/. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 100 p.

California Natural Resources Agency. 2017. Sacramento Salmon Resiliency Strategy. 17pp. Sacramento, CA. Web: http://resources.ca.gov/docs/Salmon-Resiliency-Strategy.pdf.

Camp, D. et al. 2007. "San Juan and Trabuco Creeks Steelhead Recovery Watershed Management Plan." Prepared for California Department of Fish and Wildlife by Trout Unlimited and CDM.

Campbell, E. and P. Moyle. 1991. "Historical and recent population sizes of spring run salmon in California." 155-216. In: T. Hassler (ed.). *Northeast Pacific chinook and Coho Salmon Workshop*. American Fisheries Society, Arcata, CA.

Cannata, S. 1998. "Observation of steelhead trout (*Oncorhynchus mykiss*), Coho salmon (*O. kisutch*) and water quality of the Navarro River estuary/lagoon May 1996 to December 1997." Humboldt State University Foundation.

Cannon, T. 2016. "Spring-Run Chinook Salmon – Why they Fail to Recover." *California Fisheries Blog.* Web: http://calsport.org/fisheriesblog/?p=948.

Capelli, M. 2016. "NMFS 5-Year Status Reviews: South-Central and Southern California Steelhead." National Marine Fisheries Service. Presentation to the Second Steelhead Summit, Oct. 27-28, San Luis Obispo, CA. Web: https://www.calsalmon.org/sites/default/files/files/2016_SH_Summit_Steelhead_Recovery_Acti ons_Presentations_1.pdf.

Cardno-ENTRIX. 2013. "Santa Margarita Steelhead Habitat Assessment and Enhancement Plan, Prepared for Trout Unlimited." South Coast, Santa Rosa, CA.

Carlson, S. and W. Satterthwaite. 2011. "Weakened portfolio effect in a collapsed salmon population complex." *Canadian Journal of Fisheries and Aquatic Sciences* 68: 1579-1589.

Carmona-Catot, G. et al. 2011. "Long-term captive breeding does not necessarily prevent reestablishment: Lessons learned from Eagle Lake." *Reviews in Fish Biology and Fisheries* 18(4): 1-21.

Carmona-Catot, G., and J. Weaver. 2006. "Golden trout report 2006." California Department of Fish and Game Heritage and Wild Trout Program. Sacramento CA. Carpanzano, C. 1996. "Distribution and habitat associations of different age classes and mitochondrial genotypes of *Oncorhynchus mykiss* in streams in southern California." University of California, Santa Barbara.

Casagrande, J. 2010. "Aquatic Ecology of San Felipe Lake, San Benito County, California" Master's Thesis. Paper 3803. http://scholarworks.sjsu.edu/etd_theses/3803.

Casagrande, J. 2010. "Distribution, abundance, growth and habitat use of steelhead in Uvas Creek, California." M.S. Thesis, San Jose State University. 160 pp.

Casagrande, J. 2011. "Aquatic Species and Habitat Assessment of the Upper Pajaro River, Santa Clara and San Benito Counties, CA."

Casagrande, J. 2014. "Uvas Creek Juvenile Steelhead Distribution and Abundance and Adult Observations, 2013." Prepared for the California Department of Fish and Wildlife and the National Marine Fisheries Service. 48pp.

Casagrande, J. 2015. "Uvas Creek Juvenile Steelhead Distribution and Abundance and Adult Observations, 2014." Prepared for the California Department of Fish and Wildlife and the National Marine Fisheries Service. 33pp.

Casagrande, J. 2016. "Uvas Creek Juvenile Steelhead Distribution and Abundance and Adult Observations, 2015." Prepared for the California Department of Fish and Wildlife and the National Marine Fisheries Service. 33pp.

Casagrande, J. 2017. "Uvas Creek Juvenile Steelhead Distribution and Abundance and Adult Abundance Estimates."

Cayan, D. et al. 2008. "Climate change scenarios for the California region." *Climatic Change* 87 (Suppl. 1): S21–S42.

CDFG. 1992. "Status report: California salmon." A report to the Fish and Game Commission, Sacramento, February 1992.

CDFG. 2001. "Final report on anadromous salmonid fish hatcheries in California." California Department of Fish and Game and National Marine Fisheries Service Southwest Region Joint Hatchery Review Committee. Review draft, June 27, 2001.

CDFG. 2006. Annual report. "Trinity River Basin salmon and steelhead monitoring project, 2004-2005 season." Department of Fish and Game.

CDFW Northern Region. 2015. "Map of Lower Eel Van Duzen Juvenile Coho Salmon Spatial Structure Survey, 2013-2015: Coastal Cutthroat Trout Observations." Map by B. Starks, CDFW.

CDFW Wild and Heritage Trout Program. 2015. "Fisheries Assessment Data: Snorkel Survey Data 1975-2012." https://nrm.dfg.ca.gov/ResourceAssessment/Default.aspx.

CDFW 2016. "State and Federally Listed Endangered & Threatened Animals of California." 14pp. Updated October 2016.

CDFW. 2008. "Genetic Sampling of *Oncorhynchus mykiss* in the Upper McCloud River Drainage July 8 – 11th, 2008." Heritage and Wild Trout Program. 9pp.

CDFW. 2010. "Salmon Emergency." Web: http://www.fgc.ca.gov/public/reports/DFGissues/Salmon%20Emergency.pdf. 1pp.

CDFW. 2010. "California Salmonid Stream Habitat Restoration Manual: 4th Edition." 621pp. Web: http://www.dfg.ca.gov/fish/resources/habitatmanual.asp.

CDFW. 2013. "The Historical Range of Beaver (*Castor Canadensis*) in Coastal California: An Updated Review of the Evidence." *California Fish and Game* 99(4): 193-221.

CDFW. 2014. "CDFW Releases a Snapshot of Stories and Accomplishments of 2014." https://cdfgnews.wordpress.com/2015/01/30/cdfw-releases-a-snapshot-of-stories-and- accomplishments-of-2014/.

CDFW. 2014. "Drought Response: California Department of Fish and Wildlife – Quarter 1, July-September 2014." 24pp. Web: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=92851.

CDFW. 2014. "Drought Stressor Monitoring Case Study: Coastal River/Stream and South Central Steelhead Drought Response Monitoring Summary." Web: https://www.wildlife.ca.gov/Drought/Projects/Coastal.

CDFW. 2014. "Drought Stressor Monitoring Case Study: Extended Periods of Brackish and Hyper-Saline Conditions in the Stream-Estuary Ecotone of Salmon Creek, Humboldt Bay 2014." Web: https://www.wildlife.ca.gov/Drought/Projects/Salmon-Creek.

CDFW. 2014. “California Department of Fish and Wildlife Water Branch Instream Flow Program Study Plan: Passage Assessment for Adult and Juvenile Salmonids in Lower Deer Creek, Tehama County.” 38pp. Web: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=85545.

CDFW. 2014. “Drought Stressor Monitoring Case Study: Monitoring and Rescue of Steelhead in the Uvas Creek Watershed: (southern Santa Clara County).” Web: https://www.wildlife.ca.gov/Drought/Projects/Uvas-Creek.

CDFW. 2015. “California Fish Species of Special Concern, 3rd Edition.” Web: https://www.wildlife.ca.gov/Conservation/SSC/Fishes.

CDFW. 2015. “California State Wildlife Action Plan: A Conservation Legacy for Californians.” 631pp. Web: https://www.wildlife.ca.gov/SWAP/Final.

CDFW. 2015. “CDFW Wild and Heritage Trout snorkel data.” Web: www.nrm.dfg.ca.gov/ResourceAssessment/Default.aspx.

CDFW. 2015. “Final Project Performance Report. North Central District Salmon and Steelhead Management: July 1, 2015–June 30, 2016.” Federal Award Number F15AF00397, Anadromous Sport Fish Management and Research Program, G1598076. 12pp.

CDFW. 2016. “Drought Stressor Monitoring Case Study UPDATE: Coastal River/Stream and South Central Steelhead Drought Response Monitoring Summary - Big Sur River, Monterey County.” Web: https://www.wildlife.ca.gov/Drought/Projects/Coastal/2016-Update.

CDFW. 2016. “Fall Megatable: Klamath River Basin Fall Chinook Salmon Spawner Escapement, In-River Harvest and Run-Size Estimates, 1978-2015.” Web: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=122850&inline.

CDFW. 2016. “Hatchery and Genetic Management Plan for Mad River Hatchery Winter-Run Steelhead.” Prepared for National Marine Fisheries Service. 187pp. Web: http://www.westcoast.fisheries.noaa.gov/hatcheries/hgmp/mad_river_w-steelhead_plan.html.

Center for Ecosystem Management and Restoration (CEMAR). 2009. “Steelhead/Rainbow Trout Resources of the Eel River Watershed, California.” 310pp. Web: http://www.cemar.org/eel/00_EelSH%20CEMAR09.pdf.

Chilcote, M., Goodson, K. and M. Falcy. 2011. “Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish.” *Canadian Journal of Fisheries and Aquatic Sciences*. 68(3): 511-522.

Chornesky, E. et al. 2015. “Adapting California's ecosystems to a changing climate.” *BioScience* 65(3): 247-262. doi: 10.1093/biosci/biu233.

Christie, M. et al. 2016. “A single generation of domestication heritably alters the expression of hundreds of genes.” *Nature Communications* 7:10676 doi: 10.1038/ncomms10676.

Christie, P. et al. 2014. 2014. “On the reproductive success of early-generation hatchery fish in the wild.” *Evolutionary Applications* 7: 883–896. Web: doi:10.1111/eva.12183.

Clemento, A. 2006. “Subpopulation structure of steelhead trout (*Oncorhynchus mykiss*) in the Middle Fork Eel River as determined by microsatellite DNA polymorphism.” Humboldt State University.

Clemento, A. et al. 2009. “Population Genetic Structure and Ancestry of *Oncorhynchus mykiss* Populations Above and Below Dams in South-Central California.” *Conservation Genetics* 10:1321-1336.

CMARP. 1999. “Recommendations for the implementation and continued refinement of a comprehensive monitoring, assessment, and research program.” 142 p. CMARP Steering Committee.

Coates, D. et al. 2002. “Mattole River watershed technical support document for the TMDLs for sediment and temperature.” Draft for public review. California Regional Water Quality Control Board, North Coast Region.

Cole D. and P. Landres. 1996. “Threats to wilderness ecosystems: impacts and research needs.” *Ecological Applications*. 6(1):168-184.

Cook, D. 2005. “Russian River estuary fish and macro-invertebrate studies, 2004.” Sonoma County Water Agency. 28 pp.

Cooper, E. et al. 2017. “An Estimation of Potential Salmonid Habitat and Carrying Capacity in the Upper Mainstem Eel River, California.” Master's Thesis – Humboldt State University, Arcata, CA.

Corline, N. 2014. “Zooplankton ecology and trophic resources for rearing fish on an agricultural floodplain in the Yolo Bypass, California, USA.” Master’s Thesis presented to faculty at the University of California, Davis.

Courter I. et al. 2013. “Resident rainbow trout produce anadromous offspring in a large interior watershed.” *Canadian Journal of Fisheries and Aquatic Sciences.* 70: 701-710.

Cramer, S. et al. 1995. “The status of steelhead populations in California in regards to the Endangered Species Act.” Special report submitted to the National Marine Fisheries Service on behalf of the Association of California Water Agencies. 190 p.

Crosby, A. 1986. “Ecological imperialism: the biological expansion of Europe, 900-1900.” Cambridge University Press, Cambridge.

Cucherousset, J. and J. Olden. 2011. “Ecological Impacts of Non-native Freshwater Fishes.” *Fisheries* 36(5): 215-230.

Cuthbert, R., et al. 2014. “Salinas River Basin Adult Steelhead Escapement Monitoring, 2014 Annual Report.” FishBio. Oakdale, California.

Dagit, R. (ed.) 2015b. “Summary of Anadromous Adult O. mykiss Observed in the Southern California District Population Segment. Resource Conservation District of the Santa Monica Mountains.” Poster Presented at the 2015 Salmonid Restoration Federation Conference, Santa Rosa Conference, March 13, 2015.

Dagit, R. and J. Krug. 2011. “Summary Report: Santa Monica Bay Steelhead Monitoring 2009- 2011.” Resource Conservation District of the Santa Monica Mountains.

Dagit, R., 2016b. “2015 Annual Report Summary Southern Steelhead Trout. Resource Conservation District of the Santa Monica Mountains.” NMFS Permit 15390. CDFW Permit SC- 000604.

Dagit, R., Adams, S., and S. Drill. 2009. “Die off and Current Status of Southern Steelhead Trout (*Oncorhynchus mykiss*) in Malibu Creek, Los Angeles County, USA.” *Bulletin of the Southern California Academy of Sciences* 108: 1-15.

Dagit, R., Albers, S. and S. Williams. 2009. “Topanga Creek Southern Steelhead Monitoring Snorkel Survey and Temperature Report 2009.” Prepared for the California Department of Fish and Game Contract No. P0650010.

Dagit, R., et al. 2015a. “Topanga Creek Steelhead Monitoring March 2011-December 2014.Prepared for CDFW Contract #P1050009.” Resource Conservation District of the Santa Monica Mountains, Topanga, CA. 120pp.

Dagit, R., et al. 2016a. “Updated Lifecycle Monitoring of *O. mykiss* in Topanga Creek, California.” Prepared for California Department of Fish and Game Contract No. P01350010, RCD of the Santa Monica Mountains, Topanga, CA

Daly, E. et al. 2013. “Winter Ichthyoplankton Biomass as a Predictor of Early Summer Prey Fields and Survival of Juvenile Salmon in the Northern California Current.” *Marine Ecological Progress Series* 484:203–217.

Das, T. et al. 2011. “The importance of warm season warming to western U.S. streamflow changes.” *Geophysical Research Letters* 38: L23403-L23408.

Day, K. 1996. “Life history patterns of the Mattole River steelhead, *Oncorhynchus mykiss*.” Arcata, CA, Humboldt State University.

Degroot, J., S. Hinch, and J. Richardson. 2007. “Effects of logging second- growth forests on headwater populations of coastal cutthroat trout: A 6-year, multistream, before-and-after field experiment.” *Transactions of the American Fisheries*

Society, 136, 211-226.

DeHaven, R. 2011. "Adult and juvenile steelhead population surveys, Gualala River, California." Web: http://yvm.net/vme/gualala-river/2011annualreports.html.

Deiner, K., et al. 2007. "Population structure and genetic diversity of trout (*Oncorhynchus mykiss*) above and below natural and man-made barriers in the Russian River." *Conservation Genetics*, 8.

Dettinger, M. 2005. "From Climate Change Spaghetti to Climate-Change Distributions for 21st Century California." *San Francisco Estuary and Watershed Science.*

Dettinger, M. 2008. "Climate and Hydrologic Projections Relevant to Devils Postpile." Managing Devils Postpile National Monument (DEPO) in an era of changing climate: A workshop to explore future climate variability, impacts, and adaptation options. Yosemite National Park, CA. 2008.

Docker, M. and D. Heath. 2003. "Genetic comparisons between sympatric anadromous steelhead and freshwater resident rainbow trout in British Columbia, Canada." *Conservation Genetics* 4:227-231.

Douglas, P. 1995. "Habitat relationships of oversummering rainbow trout (*Oncorhynchus mykiss*) in the Santa Ynez drainage." Ecology, Evolution, and Marine Biology. University of California, Santa Barbara.

Duffy, W. 2013. "Prairie Creek Sub-Basin Life Cycle Monitoring Project." California Cooperative Fish and Wildlife Research Unit, Humboldt State University. Final Report for CDFG Fisheries Restoration Grants Program (P0710530). 91pp.

Duffy, W. and E. Bjorkstedt. 2008. "Demographics of Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*) in Prairie Creek, California." Coastal Cutthroat Trout Symposium: Status, Management, Biology, and Conservation. *American Fisheries Society*, 2008. 9pp.

Duffy, W., Bjorkstedt, E. and C. Ellings. 2011. "Predation on Juvenile Pacific Salmon Oncorhynchus spp. In Downstream Migrant Traps in Prairie Creek, California." *North American Journal of Fisheries Management* 31:151-164. 15pp.

Dunham, J. et al. 2002. "Alien invasions in aquatic ecosystems: toward an understanding of brook trout invasions and their potential impacts on inland cutthroat trout in western North America. *Reviews in Fish Biology and Fisheries* 12:373-391.

Dunham, J. et al. 2003. "Effects of fire on fish populations: landscape perspectives on persistence of native fishes and non-native fish invasions." *Forest Ecology Management* 178:183-196.

Dunham, J., G. Vinyard, and B. Rieman. 1997. "Habitat fragmentation and extinction risk of Lahontan cutthroat trout." *North American journal of Fisheries Management* 17:1126- 1133.

Ecesis. 2015. "Salt River Restoration in the Lower Eel River Watershed." *California Society for Ecological Restoration Quarterly Newsletter*. Summer Volume 25(2): 4-7.

Eel River Forum. 2016. "Eel River Action Plan: A Compilation of Information and Recommended Actions." 139pp.

Elder, D. et al. 2002. "Salmon River Subbasin Restoration Strategy: Steps to Recovery and Conservation of Aquatic Resources." The Klamath River Basin Fisheries Restoration Task Force (Interagency Agreement 14-48-11333-98-H019).

Elliot, J. 1981. "Some aspects of thermal stress on freshwater teleosts." Page 209-245 in A.D. Pickering, ed. *Stress and fish*. Academic Press, London, U.K.

Emmett, R. et al. 1991. "Distribution and abundances of fishes and invertebrates in west coast estuaries, Volume 2: Species life histories summaries." ELMR Rep. No. 8. NOS/NOAA Strategic Environmental Assessment Division. Rockville, MD.

Everest, F. 1973. "Ecology and management of summer steelhead in the Rogue River." Oregon State Game Commission. 7,

Project AFS-31. Fisheries Research Report.

Everest, F. and D. Chapman. 1972. "Habitat selection and spatial interactions by juvenile Chinook salmon and steelhead trout in two Idaho streams." *Journal of the Fisheries Research Board of Canada* 29:91-100.

Everest, F. et al. 1986. "Abundance, behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon, as influenced by habitat enhancement." Annual Report 1985 Project No. 84-11. Prepared by U.S. Forest Service for Bonneville Power Administration, Portland, Oregon.

Everest, L. 1997. "Summer steelhead surveys North Fork Trinity River. Trinity County, California 1978-1997." Weaverville Ranger District, Shasta-Trinity National Forest.

Finger, A. et al. 2009. "Six Diagnostic Single Nucleotide Polymorphism Markers for Detecting Introgression between Cutthroat and Rainbow Trouts." *Molecular Ecology Resources* 9: 759- 763.

FishBio. 2014. "Half-Pounder History." *Fish Biology & Behavior Population Dynamics*. 5/16/2014. Web: http://fishbio.com/field-notes/population-dynamics/half-pounder-history.

FishBio. 2016. "Lagoon Life: High Risk, High Reward for California Steelhead." *Fish Report: Fisheries News and Information*. Web: http://fishbio.com/field-notes/the-fish-report/lagoons.

Fisheries and Aquatics Program. 2015. "Mattole River Coho Rescue: BLM Fisheries California." Wednesday, Feb 4. 2015. Web: http://fisheriesprogram.blogspot.com/2015/02/mattole-river- coho-rescue.html.

Fontaine, B. 1988. "An evaluation of the effectiveness of instream structures for steelhead trout rearing habitat in the Steamboat Creek basin." Master's thesis. Oregon State University, Corvallis, OR.

Foott, J. and R. Walker. 1991. "Disease survey of Trinity River salmon smolt populations, 1991 report." in U.S. Department of the Interior, F. A. W. S., California-Nevada Fish Health Center.

Foott, J. et al. 2002. "FY2001 investigational report: juvenile Chinook health monitoring in the Trinity River, Klamath river, and estuary." June- August 2001. U.S. Fish and Wildlife Service, California- Nevada Fish Health Center, Anderson, CA.

Foott, J., R. Harmon and R. Stone. 2003. "FY2002 investigation report: *Ceratomyxosis* resistance in juvenile Chinook salmon and steelhead from the Klamath River." U.S. Fish and Wildlife Service California- Nevada Fish and Health Center, Anderson, CA.

Foott, J., R. Harmon, and R. Stone. 2004. "FY 2003 Investigational Report: Abundance of *Ceratomyxa shasta* in Iron Gate and Copco reservoirs." U.S. Fish and Wildlife Service California-Nevada Fish Health Center, Anderson, CA.

Frankham, R. 2005. "Genetics and extinction." *Biological Conservation* 126:131-140. Fraser, D. 2008. "How Well Can Captive Breeding Programs Conserve Biodiversity? A Review of Salmonids." *Evolutionary Applications*, Synthesis: 1-52.

Fry, D. 1973. "Anadromous fishes of California." California Department of Fish & Game. 111pp.

Fuller, J. 2011. "Extended Residency and Movement Behavior of Juvenile Steelhead (*Oncorhynchus mykiss)* in the Russian River Estuary, California." Master's Thesis submitted to Humboldt State University, Arcata, CA. 109pp.

Gale, D. and D. Randolph. 2000. "Lower Klamath River Sub-Basin Watershed Restoration Plan." Yurok Tribal Fisheries and Watershed Restoration Programs. Klamath, CA.

Gale, D. et al. 1998. "Assessment of anadromous fish stocks in Blue Creek, Lower Klamath River, California, 1994- 1996." Habitat Assessment and Biological Monitoring Division, Technical Report No. 4. Klamath, CA, Yurok Tribal Fisheries Program.

Gall, G., B. Bentley and R. Nuzum. 1990. "Genetic isolation of Steelhead Rainbow Trout in Kaiser and Redwood Creeks, California." *California Fish and Game* 76(4):216-223.

Gallagher, S. 2000. "Results of the 2000 steelhead (*Oncorhynchus mykiss*) fyke trapping and stream resident population estimations and predictions for the Noyo River, California with comparison to some historic information." CDFG Steelhead Research and Monitoring Program. 45 pp.

Gallagher, S. and D. Wright. 2007. "A regional approach to monitoring salmonid abundance trends: a pilot project for the application of the California coastal salmonid monitoring plan in coastal Mendocino County." California Department of Fish and Game Coastal Watershed Planning and Assessment Program. Fortuna, California.

Gallagher, S., Thompson, S. and D. Wright. 2012. "Identifying factors limiting coho salmon to inform stream restoration in coastal Northern California." *California Fish and Game* 98: 185- 210.

Garrison, P. 2002. "2001-2002 Annual Report: Summer steelhead snorkel survey of South Fork Trinity River, Project Ic1." CDFG, Steelhead Research and Monitoring Program.

Garwood, J., Larson, M. and M. Reneski. 2014. "2013-2014 Salmonid Redd Abundance and Juvenile Salmonid Spatial Structure in the Smith River Basin, California and Oregon." Report prepared by the California Department of Fish and Wildlife. 45pp.

Garza, C. et al. 2014. "Population Structure of Steelhead in Coastal California." *Transactions of the American Fisheries Society* 143(1): 134-152.

Garza, J. 2004. "Population structure and history of steelhead trout in California." North Pacific Anadromous Fisheries Commission, Technical Report No. 5.

Garza, J. and D. Pearse. 2008. "Population Genetic Structure of *Oncorhynchus mykiss* in the California Central Valley: Final Report for California Department of Fish and Game."

Garza, J. C. and A. Clemento. 2007. "Population Genetic Structure of Oncorhynchus mykiss in the Santa Ynez River, California." Final Report for Project Partially Funded by the Cachuma Conservation Release Board. 54pp. Web: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/dom ains/south_central_southern_california/garza clemento santa_ynez_river_genetics_rptort_20 07.pdf.

Garza, J. C. and D. Pearse. n.d. "Population genetic structure of *Oncorhynchus mykiss* in the California Central Valley." Final report for California Department of Fish and Game Contract # PO485303 to NMFS Southwest Fisheries Science Center.

Garza, J. C. et al. 2014. "Population Structure of Steelhead in Coastal California." *Transactions of the American Fisheries Society* 143(1): 134-152.

Gerstung, E. 1980. "1979 annual report of the Threatened Salmonids Project." Unpubl. Rep., Calif. Dept. Fish and Game, Sacramento.

Gilbert, C. 1913. "Age at maturity of the Pacific coast salmon of the genus *Oncorhynchus*." Bulletin, Bureau of Fisheries 32:1-22.
Giovannetti, S. and M. Brown. 2007. "Central Valley steelhead and late fall-run Chinook salmon redd surveys on Clear Creek, California 2007." U.S. Fish and Wildlife Service. Red Bluff, CA.

Girman, D. and J. C. Garza. 2006. "Population structure and ancestry of *O. mykiss* populations in South-Central California based on genetic analysis of microsatellite data." California Department of Fish and Game and Pacific State Marine Fisheries Commission.

Good, T., Waples, R., and P. Adams (eds.). 2005. "Updated status of federally listed ESUs of West Coast salmon and steelhead." NOAA Technical Memo. NMFS-NWFSC-66, 598 pp.

Grantham, T. et al. 2012. "The Role of Streamflow and Land Use in Limiting Oversummer Survival of Juvenile Steelhead in California Streams." *Transactions of the American Fisheries Society* 141: 585–598.

Gregory, S. and P. Bisson. 1997. "Degradation and loss of anadromous salmonid habitat in the Pacific Northwest." Pages 277-314 in D.J. Stouder, P.A. Bisson and R.J. Naiman (eds.), *Pacific salmon and their ecosystems: status and future options*.

Chapman and Hall, New York.

Gresswell, R. 1999. "Fire and aquatic ecosystems in forested biomes of North America." *Transactions of the American Fisheries Society* 128:193–221.

Griswold, K. 2006. "Report on the Coastal Cutthroat Trout Science Workshop: Compilation of Research and Monitoring Needs for Coastal Cutthroat Trout Throughout their Distributional Range." Report to Pacific States Marine Fisheries Commission.

Groot and L. Margolis, (eds.). *Pacific salmon life histories*. University of British Columbia Press. Vancouver, B.C.

Grossman, G. 2016. "Predation on Fishes in the Sacramento–San Joaquin Delta: Current Knowledge and Future Directions." *San Francisco Estuary and Watershed Science* 14(2): 1-23.

Haak, A. et al. 2010. "Conserving Peripheral Trout Populations: The Values and Risks of Life on the Edge." *Fisheries* 35:11, 530-549.

Haak, A. et al. 2010. "The potential influence of changing climate on the persistence of salmonids of the Inland West." U.S. Geological Survey Open-File Report 2010-1236, 74pp.

Hagar, J. et al. 1995. "The status of steelhead populations in California in regards to the Endangered Species Act." Special report submitted to the National Marine Fisheries Service on behalf of the Association of California Water Agencies. 190 p.

Hallock, R. and D. Fry. 1967. "Five species of salmon, *Oncorhynchus*, in the Sacramento River, California." *California Fish and Game*, 53, 5-22.

Hampe, A. and R. Petit. 2005. "Conserving biodiversity under climate change: the rear edge matters." *Ecological Letters* 8:461–67.

Hanak, E. et al. 2011. *Managing California's Water: From Conflict to Reconciliation*. Public Policy Institute of California. San Francisco, CA.

Harding, J. 2015. "Cruise Report for OS1401, Juvenile Salmon Ocean Ecology." *R/V Ocean Starr*, July 5-24, 2014. National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division. 20pp. Web:https://swfsc.noaa.gov/uploadedFiles/Divisions/FED/Salmo n_Ecology/resources/cruise_rep ort_OS1401.pdf.

Hartman, G. 1965. "The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*)." *Journal of the Fisheries Research Board of Canada*, 20, 1035-1081.

Harvey, B., J. White, and R. Nakamoto. 2002. "Habitat relationships and larval drift of native and non-indigenous fishes in neighboring tributaries of a coastal California river." *Transactions of the American Fisheries Society*, 131, 159-170.

Hassrick, J. et al. (*In prep.*). "Physical and Environmental Determinants of Juvenile Chinook Salmon Dispersal in the Northern California Current."
Hawkins, D. and T. Quinn. 1996. "Critical swimming velocity and associated morphology of juvenile coastal cutthroat trout (*Oncorhynchus clarki clarki*), steelhead trout (*Oncorhynchus mykiss*), and their hybrids." *Canadian Journal of Fisheries and Aquatic Science*, 53, 1487-1496.

Hayes et al. 2011. "Down, Up, Down, and "Smolting" Twice? Seasonal Movement Patterns by Juvenile Steelhead (*Oncorhynchus mykiss*) in a Coastal Watershed with a Bar Closing Estuary." *Canadian Journal of Fisheries and Aquatic Sciences* 68: 1341-1350.

Hayes, S. and J. Kocik. 2014. "Comparative estuarine and marine migration ecology of Atlantic salmon and steelhead: blue highways and open plains." *Reviews in Fish Biology and Fisheries*. DOI 10.1007/s1160-14-9348-8.

Hayes, S. et al. 2008. "Steelhead growth in a small Central California watershed: upstream and estuarine rearing patterns." *Transactions of the American Fisheries Society* 137: 114-128.

Hayes, S. et al. 2016a. “Half pounders, Climate Change and Blob, Blob, Blob.” NOAA Southwest Fisheries Science Center. Presentation for the 2016 Pacific Coast Steelhead Management Meeting, Pacific Grove, March 2016. Web: www.psmfc.org/steelhead/2016/hayes_PSMFC_Hayes_steelhead_talk.pdf.

Hayes, S. et al. 2016b. “Observations of Steelhead in the California Current Lead to a Marine- based Hypothesis for the ‘Half-Pounder’ Life History, with Climate Change Implications for Anadromy.” *North Pacific Anadromous Fish Commission Bulletin.* 6: 97-105. Web: https://www.researchgate.net/publication/312185520_Observations_of_Steelhead_in_the_California_Current_Lead_to_a_Marine-Based_Hypothesis_for_the_Half-Pounder_Life_History_with_Climate_Change_Implications_for_Anadromy.

HDR Engineering. 2013. “Los Padres National Forest Steelhead Monitoring, Tracking and Reporting Program.” Final Plan. Prepared for U.S. Forest Service, Los Padres National Forest.

Heath et al. 2010. “Environmental Factors Associated with Reproductive Barrier Breakdown in Sympatric Trout Populations on Vancouver Island.” *Evolutionary Applications* 3: 77-90.

Hedgecock, D. 2002. “Documenting biodiversity of coastal salmon (Oncorhynchus spp.) in Northern California.” Bodega Marine Laboratory, UC Davis report to the Sonoma County Water Agency, Santa Rosa, CA.

Hendrickson, G., A. Carleton, and D. Manzer. 1989. “Geographic and seasonal distribution of the infective stage of *Ceratomyxa shasta* (*Myxozoa*) in Northern California.” *Diseases of Aquatic Organisms*, 7, 165-169.

Herbst, D. et al. 2012. “Effects of livestock exclusion on in-stream habitat and benthic invertebrate assemblages in montane streams.” *Freshwater Biology*. 57, 204-217.

Hill, A., Sullivan, R., and E. Wiseman. 2015. “Trinity River Tributary Summer Steelhead and Spring Chinook Snorkel Surveys 1990-2014: Canyon Creek, North Fork Trinity River, South Fork Trinity River, and New River.” CDFW Trinity River Project, Weaverville Office. 26pp. CDFW Document Library, Klamath/Trinity Program Biological Information Documents. Web: https://nrm.dfg.ca.gov/documents/ContextDocs.aspx?cat=KlamathTrinity.

Hiser, C. 1979. “Annual Report: Iron Gate Salmon and Steelhead Hatchery and Bogus Rearing Pond 1977-78.” California Department of Fish and Game, Inland Fisheries Admin Report. No. 79-8. 23pp.

Hiser, C. 1985. “Annual Report: Iron Gate salmon and steelhead hatchery 1982-83.” Inland Fisheries Administrative Report No. 85-02. 23 pp.

Hodge et al. 2016. “Life History Diversity in Klamath River Steelhead.” *Transactions of the American Fisheries Society.* 145: 227-238.

Hodge, B., Wilzbach, M. and W. Duffy. 2014. “Potential Fitness Benefits of the Steelhead Half- Pounder Life History in Klamath River Steelhead.” *Transactions of the American Fisheries Society* 143(4): 864-875.

Holmes et al. 2014. “Seasonal Microhabitat Selectivity by Juvenile Steelhead in a Central California Coastal River.” *California Fish and Game* 100(4): 590-615.

Holmes, R. and W. Cowan. 2014. “Instream Flow Evaluation Steelhead Spawning and Rearing Big Sur River, Monterey County, CA.” CDFW Water Branch, July, 2014. Web: https://www.wildlife.ca.gov/conservation/watersheds/instream-flow/studies/big-sur-study.

Hopelain, J. 1998. “Age Growth, and Life History of Klamath River Basin Steelhead Trout (*Oncorhynchus mykiss irideus*) as Determined from Scale Analysis.” CDFW Inland Fisheries Division Administrative Report No. 98-3. Web: http://aquaticcommons.org/2898/1/IFD_AdminReport98-3.pdf.

Hopelain, J. 2001. “Lower Klamath River angler creel census with emphasis on upstream migrating fall Chinook salmon, coho salmon, and steelhead trout during July through October, 1983-1987.” Inland Fisheries Administrative Report 01-1.

Hopelain, J., G. Flosi, and S. Downie. 1997. “Stream monitoring progress report for five small streams in Northwestern

California, Lawrence, Shaw, Oil, Rattlesnake, and Green Ridge Creeks 1991 through 1995." Inland Fisheries Administrative Report 97-6.

Hovey, T. 2004. "Current status of southern steelhead/rainbow trout in San Mateo Creek, California." *California Fish and Game* 90: 140-154.

Hubbell, P. 1973. "Program to identify and correct salmon and steelhead problems in the Trinity River basin." California Department of Fish and Game report to the Trinity River Fish and Wildlife Task Force. Sacramento CA.

Intergovernmental Panel on Climate Change (IPCC). 2014. *Climate Change 2014: Synthesis Report.* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri, R. and L. Meyer (eds.). Geneva, Switzerland, 151 pp.

Jacobson, S., et al. 2014. "Genetic Analysis of Trout (*Oncorhynchus mykiss*) in Southern California Coastal Rivers and Streams." Final Report for California Department of Fish and Wildlife Fisheries Restoration Grant Program; Project No. 0950015. 30pp

Jeffres, C. et al. 2016. "From Subduction to Salmon: Understanding Physical Process and Ecosystem Function in Aquatic Ecosystems." PhD dissertation. University of California, Davis.

Jensen, D. et al. 2009. "Impact of Fine Sediment on Egg-To-Fry Survival of Pacific Salmon: A Meta-Analysis of Published Studies." *Reviews in Fisheries Science* 17(3): 348–359.

Johnson, R. et al. 2012. "Managed Metapopulations: Do Salmon Hatchery 'Sources' Lead to In- River 'Sinks' in Conservation?" *PLoS One*. 7(2): e28880.

Johnson, S. 3/14/2016. "Steelhead Trout Return to Lower Alameda Creek." *East Bay Express*. Web: http://www.eastbayexpress.com/SevenDays/archives/2016/03/14/steelhead-trout-return-to- lower-alameda-creek.

Jones, W. and E. Ekman. 1980. "Summer steelhead management plan-Middle Fork of the Eel River." California Department Fish and Game and U.S. Forest Service. 48 pp.

Katz, J. et a. 2013. "Impending extinction of salmon, steelhead, and trout (*Salmonidae*) in California." *Environmental Biology of Fishes* 96:1169-1186. DOI 10.1007/s10641-012-9974-8.

Katz, J. et al. *In press*. "Floodplain Farm Fields Provide Novel Rearing Habitat for Chinook Salmon." *PLoS One*.

Kauffman, J. and W. Krueger. 1984. "Livestock impacts on riparian ecosystems and streamside management implications... A Review." *Journal of Range Management* 37(5): 1-9. Kauffman, J., W. Krueger, and M. Vavra. 1983. "Impacts of cattle on streambanks in North- eastern Oregon." *Journal of Range Management* 36(6): 683-685.

Keeley, J. 2006. "Fire in California's Ecosystems: South Coast Bioregion." *In*. N. G. Sugihara, J. W. V. Wagendonk, K. E. Shaffer, J. Fites-Kaufman, A. E. Those (eds.). *Fire in California's Ecosystems*. University of California Press.

Keller, E., D. Valentine, and D. Gibbs. 1997. "Hydrological response of small watershed following the southern California Painted Cave fire of June 1990." *Hydrological Processes* 11, 401-414.

Kelley, E. 2008. "Steelhead Trout Smolt Survival in the Santa Clara and Santa Ynez Rivers." Prepared for the California Department of Fish and Game. University of California, Santa Barbara.

Kendall, N. et al. 2015. "Anadromy and residency in steelhead and rainbow trout (*Oncorhynchus mykiss):* a review of the processes and patterns." *Canadian Journal of Fisheries and Aquatic Sciences* 72: 319-342.

Kennedy, B. 2009. "Morphological, Physiological, and Genetic Techniques for Improving Field Identification of Steelhead, Coastal Cutthroat Trout, and Hybrid Smolts." *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 1:45-56.

Kesner, W. and R. Barnhart. 1972. "Characteristics of the fall-run steelhead trout (*Salmo gairdneri gairdneri*) of the

Klamath River system with emphasis on the half-pounder." *California Fish and Game*, 58.

Kier, M. C. 2016. "Escapement and Proportion of Natural Origin Salmonids Contributing to Total Escapement." Trinity River Restoration Program (TRRP) Performance Measure. TRRP, Weaverville, California. http://odp.trrp.net/Data/Documents/Details.aspx?document=2285.

Kier, M. C. and J. Hileman. 2016. "Annual Report: Trinity River Basin Salmon and Steelhead Monitoring Project: Chinook and Coho Salmon and Fall-Run Steelhead Run-Size Estimates Using Mark-Recapture Methods, 2016-17 Season." Report to the Trinity River Restoration Program (U.S. BOR Agreement R13AC20027). California Department of Fish and Wildlife, Redding, CA. 96pp. http://odp.trrp.net/Data/Documents/Details.aspx?document=2299.

Kier, M. C. and J. Hileman. 2016. "Annual Report: Trinity River Basin Salmon and Steelhead Monitoring Project – Chinook and Coho Salmon and Fall-Run Steelhead Run-Size Estimates using Mark-Recapture Methods, 2015-2016 Season." 96pp. Web: https://nrm.dfg.ca.gov/documents/contextdocs.aspx?cat=klamathtrinity.

Kiernan, J., and P. Moyle. 2012. "Flows, droughts, and aliens: factors affecting the fish assemblage in a Sierra Nevada, California, stream." *Ecological Applications* 22:1146-1161.

Kiernan, J., Moyle, P., and Crain, P. 2012. "Restoring native fish assemblages to a regulated California stream using the natural flow regime concept." *Ecological Applications* 22: 1472– 1482. Web: doi:10.1890/11-0480.1.

Kostow, K. 2004. "Differences in juvenile phenotypes and survival between hatchery stocks and a natural population provide evidence for modified selection due to captive breeding." *Canadian Journal of Fisheries and Aquatic Science*, 61, 577- 589.

Kostow, K. 2008. "Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies." *Reviews in Fish Biology and Fisheries*.

Kovach, R. et al. 2015. "Genetic diversity is related to climatic variation and vulnerability in threatened bull trout." *Global Change Biology* 21(7): 2510–2524.

Krug, J., Bell, E., and R. Dagit. 2012. "Growing up fast in a small creek: Diet and Growth of a Population of *Oncorhynchus mykiss* in Topanga Creek, California." *California Fish and Game* 98(1): 38-46.

Kueffer, C, and N. Kaiser-Bunbury. 2014. "Reconciling conflicting perspectives for biodiversity conservation in the Anthropocene." *Frontiers in Ecology and the Environment* 12: 131-137. Doi: 10.1890/120201.

Lackey, R., D. Lach, and S. Duncan. 2006. *Salmon 2100: the future of wild Pacific salmon*. American Fisheries Society, Bethesda, MD.

Lafferty, K. 2005. "Assessing estuarine biota in Southern California." USDA Forest Service General Technical Report. PSW-GTR-195. LaRivers, I. 1962. *Fishes and fisheries of Nevada*. Nevada State Fish and Game Commission, Reno, Nevada. 782 pp.

Larson, Z. 2013. "Operation of Dual Frequency Identification Sonar (Didson) to Monitor Adult Anadromous Fish Migration in the Smith River, California: 2-Year Pilot Study. Final report to the California Department of Fish and Wildlife and Del Norte County, Contract: P0910315. Zach Larson and Associates, Crescent City, CA. 42pp.

Larson, Z. 2013. "Use of Dual Frequency Identification Sonar to Monitor Steelhead Escapement in the Smith River, California, 2012-2013." Web: http://www.casalmon.org/pdfs/Smith%20River.2012-13.P1281016_SMITH%20RIVER%20DIDSON%20FINAL%20REPORT_STEELHEAD%20C ARD.pdf."

Lee, D. 2015. *The Half-Pounder, a Steelhead Trout: Life History and Fly Fishing.* Think Publications, El Dorado Hills, CA. 226pp.

Lehr, S. 2016. "Department of Fish and Wildlife 2014-2015 Drought Response." Presentation for Pacific Steelhead Management Conference, March 2016, Pacific Grove, CA. Web: http://www.psmfc.org/steelhead/2016/lehr_STH_Drought_Briefing_3-9-2016.pdf.

Leidy, R. and G. Leidy. 1984a. "Life stage periodicities of anadromous salmonids in the Klamath River basin, Northwestern California." Page 39 in US Department of Interior. Division of Ecological Services, Sacramento, CA.

Leitwein, M., Garza, C., and D. Pearse. 2016. "Ancestry and adaptive evolution of anadromous, resident, and adfluvial rainbow trout (*Oncorhynchus mykiss*) in the San Francisco Bay area: application of adaptive genomic variation to conservation in a highly impacted landscape." *Evolutionary Applications*. DOI: 10.1111/eva.12416.

Lemly, D. 1998. "Bacterial growth on stream insects: potential for use in bioassessment." *Journal of the North American Benthological Society*. 17(2):228-238.

Levin, P., R. Zabel and J. Williams. 2001. "The road to extinction is paved with good intentions: negative association of fish hatcheries with threatened salmon." *Proceedings of the Royal Society*, London: 268:1153-1158.

Lindley, S. et al. 2006. "Historical Population Structure of Central Valley Steelhead and its Alteration by Dams." *San Francisco Estuary and Watershed Science*.

Lindley, S. et al. 2007. "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin." *San Francisco Estuary & Watershed Science* 5(1). Article 4: California Bay-Delta Authority Science Program and the John Muir Institute of the Environment.

Lindley, S. et al. 2009. "What Caused the Sacramento River Fall Chinook Stock Collapse?" NOAA Technical Memorandum: NOAA-TM-NMFS-SWFSC-447. 125pp. Web: https://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-447.PDF.

Lisle, T. 1982. "The recovery of stream channels in north coastal California from recent large floods." Hashhagen, K. (ed.). *In Habitat Disturbance and Recovery, Proceedings of a Symposium*. California Trout Inc., San Francisco, CA.

Lowe, S. et al. 2000. "100 of the worst invasive alien species; a selection from the global invasive species data base." Invasive Species Specialist Group, IUCN. Auckland, NZ. 12 pp.

Lusardi, R. and P. Moyle. *In press*. "Two-way trap and haul as a conservation strategy for anadromous salmonids." *Fisheries*.

Lusardi, R. et al. 2015. "Threat evolution: Negative feedbacks between management action and species recovery in threatened trout (*Salmonidae*)." *Reviews in Fisheries Biology* 25: 521-535.

Lynch, A. et al. 2016. "Climate Change Effects on North American Inland Fish Populations and Assemblages." *Fisheries* 41(7): 346-361.

Mad River Alliance. 2014. "Mad River Summer Steelhead Report – 2013." 7pp. Mad River Alliance. 2016. "Mad River Summer Steelhead Report – 2014." 8pp.

Mad River Watershed Assessment. 2010. Final report. Prepared by Stillwater Sciences, Arcata, CA.

Madej, M. 2011. "Analysis of Trends in Climate, Streamflow, and Stream Temperature in North Coastal California." *Fourth Interagency Conference on Research in the Watersheds*, 26-30 September, 2011. Fairbanks, AK. 6pp.

Mantua, N. 2015. "Shifting Patterns in Pacific Climate, West Coast Salmon Survival Rates, and Increased Volatility in Ecosystem Services." *Proceedings of the National Academy of Sciences* 112(35): 10823-10824.

Mantua, N. et al. 2015. "Response of Chinook salmon to climate change." *Nature Climate Change* (5): 613-615.

Martin, B. et al. 2017. "Phenomenological vs. biophysical models of thermal stress in aquatic eggs." *Ecology Letters 20*(1): 50-59.

Mastrandrea, M., et al. 2009. "Current and future impacts of extreme events." California Climate Change Center Draft Report, March 2009: 81 pp.

Matthews, K. 1996a. "Diel movement and habitat use of California golden trout in the Golden Trout Wilderness." *Transactions of the American Fisheries Society*, 125, 78- 86.

Matthews, K. 2010. "California Golden Trout and Climate Change: Is Their Stream Habitat Vulnerable to Climate Warming?" Wild trout Symposium. 81-87.

Matthews, K. and N. Berg. 1997. "Rainbow trout responses to water temperature and dissolve oxygen stress in two southern California stream pools." *Journal of Fish Biology* 50: 40-67.

Mattole Salmon Group (MSG). 2005. "State of the Salmon report 2005." Mattole Salmon Group. Report to the California Coastal Conservancy.

Mattole Salmon Group. 2012. "Mattole Salmon Group Summer Steelhead Dive Final Report, 2012." Web: http://www.mattolesalmon.org/wp- content/uploads/2015/01/MSG_SSD_Results_2012.pdf.

Mattole Salmon Group. 2014. "Juvenile Dives." Web: http://www.mattolesalmon.org/programs/fisheries/monitoring/juvenile-dives/.

Mattole Salmon Group. 2015. "Habitat Restoration – Estuary: Heliwood." Web: http://www.mattolesalmon.org/programs/habitat/restoration/estuary/.

Mattole Salmon Group. 2015. "Spawner Surveys." Web: http://www.mattolesalmon.org/programs/fisheries/monitoring/spawner-surveys/.

Mattole Salmon Group. 2015. "Summer Steelhead Dive." Web: http://www.mattolesalmon.org/programs/fisheries/monitoring/summer-steelhead-dive/.

Mattole Salmon Group. 2016. "History of the Mattole Estuary." Web: http://www.mattolesalmon.org/about/historical-estuary/.

Mattole Salmon Group. 2016. "Steelhead." Web: http://www.mattolesalmon.org/resources/local- fish/steelhead/.

May, S. 2006. "Historical Population Structure of Central Valley Steelhead and its Alteration by Dams." *San Francisco Estuary and Watershed Science*, 4(1): 1-19.

Mazur, L. and C. Milanes, eds. and comps. 2009. "Indicators of Climate Change in California. Office of Environmental Health Hazard Assessment, California." 197 pp.

McCullough, D. 1999. "A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon." Columbia River Inter-Tribal Fish Commission. A report to the U.S. Environmental Protection Agency, Seattle, WA. 291.

McElhany, P. et al. 2000. "Viable salmonid populations and the recovery of Evolutionary Significant Units." NOAA Technical Memorandum NMFS-NWFSC- 42. 156 pp.

McEwan D. and T. Jackson. 1996. "Steelhead Restoration and management plan for California." California Department of Fish and Game.

McEwan, B. et al. 2007. "Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin." *San Francisco Estuary and Watershed Science* 5(1): 4.

McEwan, D. 2001. "Central Valley Steelhead." in *Contributions to the Biology of Central Valley Salmonids*, California Department of Fish and Game Fish Bulletin 179.

McMichael, G. 1999. "Behavioral interactions among hatchery-reared steelhead and wild *Oncorhynchus mykiss* in natural streams." *North American Journal of Fisheries Management*, 19, 948-956.

Meehan, W. (Ed.) 1991. "Influences of forest and rangeland management on salmonid fishes and their habitats." *American*

Fisheries Society Special Publication 19.

Meek, M. et al. 2016. "Sequencing improves our ability to study threatened migratory species: Genetic population assignment in California's Central valley Chinook salmon." *Ecology and Evolution* 6: 7706-7716.

Merz, J. 2002. "Seasonal feeding habits, growth, and movement of steelhead trout in the lower Mokelumne River, California." *California Fish and Game*, 88, 95-111.

Merz, J. and C. Vanicek. 1996. "Comparative feeding habits of juvenile chinook salmon, steelhead, and Sacramento squawfish in the lower American River, California." *California Fish and Game* 82, 149–159.

Miller, M. et al. 2014. "Infectious Disease, Shifting Climates, and Opportunistic Predators: Cumulative Factors Potentially Impacting Wild Salmon Declines." *Evolutionary Applications* 7:812-855.

Mills, T. et al. 1997. "California salmon and steelhead: beyond the crossroads." Pages 91–111 in D. J. Strouder, P.A. Bisson, J. Naiman, (eds). *Pacific salmon and their ecosystems*. New York, Chapman and Hall.

Moffett, J. and S. Smith. 1950. "Biological investigations of the fishery resource of Trinity River, California." U.S. Department of Interior, Fish and Wildlife Service. Special Scientific Report: Fisheries No. 12.

Montgomery, S. 2003. *King of fish: the thousand-year run of salmon*. Westview Press, Cambridge MA.

Moore, J. et al. 2014. "Life-History Diversity and Its Importance to Population Stability and Persistence of a Migratory Fish: Steelhead in Two Large North American Watersheds." *Journal of Animal Ecology* 83: 1035-1046.

Moore, M. 1980a. "Factors Influencing the Survival of Juvenile Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) in the Ventura River, California." M.S. Thesis. Humboldt State University.

Morelli, T. 2009. "Evaluating Climate Change in the Eastern Sierra Nevada. Pacific Southwest Research Station." USDA Forest Service.

Moser, S., et al. 2009. "The future is now: An update on climate change science impacts and response options for California." California Climate Change Center Draft Report, March 2009: 114 pp.

Mount, J. 1995. *California rivers and streams*. University of California Press, Berkeley, CA. 313 pp.

Moyle, P. 1979. *Inland Fishes of California*, 1st Edition. Berkeley, University of California Press.

Moyle, P. 2002. *Inland Fishes of California*, 2nd Edition. Berkeley, University of California Press.

Moyle, P. and D. Baltz. 1985. "Microhabitat use by an assemblage of California stream fishes: Developing criteria for instream flow determinants." *Transactions of the American Fisheries Society*, 114.

Moyle, P. and J. Israel. 2005. "Untested assumptions: effectiveness of screening diversions for conservation of fish populations." *Fisheries* 30 (5): 20-28.

Moyle, P. and M. Marchetti. 2006. "Predicting invasion success: freshwater fishes in California as a model." *Bioscience* 56:515-524.

Moyle, P. and J. Smith. 1998. "Freshwater fishes of the Central California Coast." Pages 17-22 in N. Chiariello and R. F. Dasmann, (eds.). *Symposium on biodiversity of the Central California Coast Association* for the Golden Gate Biosphere Reserve, San Francisco.

Moyle, P. et al. 1989. "Fish Species of Special Concern in California." 222pp.

Moyle, P. et al. 1991. "Fishes of Bly Tunnel, Lassen County, California." *Great Basin Naturalist*, 51, 267-271.

Moyle, P., J. Katz and R. Quiñones. 2011. "Rapid decline of California's native inland fishes: a status assessment." *Biological Conservation* 144: 2414–2423.

Moyle, P. et al. 2013. "Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach." *PLoS ONE* 8(5): e63883. doi:10.1371/journal.pone.0063883.

Moyle, P. et al. 1995. "Fish species of special concern in California, 2nd Edition." California Department of Fish and Game.

Moyle, P. et al. 2008. *Salmon, Steelhead, and Trout in California. Status of an Emblematic Fauna.* 316pp.

Moyle, P. et al. 2012. 2012. "Projected effects of future climates on freshwater fishes of California." California Energy Commission, Public Interest Research Program. Publication number: CEC-500-2012-028.

Moyle, P. et al. 2015. "Fish Species of Special Concern in California, 3rd edition." California Department of Fish and Wildlife. Sacramento, CA.

Moyle, Peter, Lusardi, Robert A, Samuel, Patrick J, Katz, Jacob V. E. August 2017. *State of the Salmonids: Status of California's Emblematic Fishes 2017* UC Davis Watershed Sciences Center. A report commissioned by California Trout. 579 pp.

Muhlfeld, C. et al. 2014. "Invasive hybridization in a threatened species is accelerated by climate change." *Nature Climate Change* (4): 620-624.

Myrick, C. and J. Cech. 2004. "Temperature effects on juvenile anadromous salmonids in California's Central Valley: what don't we know." *Reviews in Fish Biology and Fisheries*, 14, 113-123.

Myrick, C., and J. Cech, Jr. 2000. "Temperature influences on California rainbow trout physiological performance." *Fish Physiology and Biochemistry*. 22: 245–254.

Nakamoto, R. 1994. "Characteristics of Pools Used by Adult Summer Steelhead Oversummering in the New River, California." *Transactions of the American Fisheries Society* 123(5): 757-765.

Naman, S. and C. Sharpe. 2012. "Predation by Hatchery Yearling Salmonids on Wild Subyearling Salmonids in the Freshwater Environment: A Review of Studies, Two Cast Histories, and Implications for Management." *Environmental Biology of Fishes* 94:21-28.

NMFS. 2012. "Southern California Steelhead Recovery Plan. National Marine Fisheries Service. Southwest Regional Office, Long Beach, California." 563 pp. 249pp.
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/dom ains/south_central_southern_california/southern_california_steelhead_recovery_plan_executive_ summary_012712.pdf.

NMFS. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, California. 477pp. Web:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/dom ains/south_central_southern_california/2013_scccs_recoveryplan_final.pdf.

NMFS. 2014b. "Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead." Sacramento, CA. Web:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/dom ains/california_central_valley/final_recovery_plan_07-11-2014.pdf.

National Marine Fisheries Service (NMFS). 2015. "Garcia River: Salmon and Steelhead Recovery." 4pp.

NMFS. 2015. "Garcia River: Salmon and Steelhead Recovery." 4pp.

National Marine Fisheries Service. 2016. "5-Year Review: Summary and Evaluation of South- Central California Coast Steelhead Distinct Population Segment." 75pp. Web:

http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/201 6_sccc-steelhead.pdf.

NMFS. 2016a. "5-Year Review: Summary and Evaluation California Central Valley Steelhead Distinct Population Segment." Southwest Fisheries Science Center, Santa Cruz. Web: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/201 6_cv-steelhead.pdf.

NMFS. 2016b. "5-Year Review: Summary and Evaluation of Southern California Coast Steelhead Distinct Population Segment." National Marine Fisheries Service. West Coast Region. California Coastal Office, Long Beach. California. 75pp.

NMFS. 2016c. "Final Coastal Multispecies Recovery Plan." National Marine Fisheries Service, West Coast Region, Santa Rosa, California. 900pp.
Web:http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/north_central_california_coast/Final%20Materials/V ol%20III/vol._iii_nc_steelhead_coastal_multispecies_recovery_plan.pdf.

NMFS. 2016. "Steelhead Trout *(Oncorhynchus mykiss)*." Web: http://www.fisheries.noaa.gov/pr/species/fish/steelhead-trout.html.

National Research Council (NRC). 2004. "Endangered and threatened fishes in the Klamath River basin: causes of decline and strategies for recovery." Washington D.C., The National Academies Press.

Needham, P. and R. Gard. 1959. "Rainbow trout in Mexico and California, with notes on the cutthroat trout series." University of California Publication, Zoology, 67, 123 pp.

Neillands, W. 2001. "Natural hybridization between coastal cutthroat trout (*Oncorhynchus clarki clarki*) and steelhead trout (*Oncorhynchus mykiss*) within Redwood Creek, California." Thesis (M.S.) Humboldt State University, Arcata, CA.

Nelson, J. 2016. "California Steelhead: Management, Monitoring and Recovery Efforts." Web: http://www.psmfc.org/steelhead/2016/Nelson_2016_CA_Status.pdf. Nelson, J. CDFW. 2016. "California Steelhead: Management, Monitoring and Recovery Efforts." Web: http://www.psmfc.org/steelhead/2016/Nelson_2016_CA_Status.pdf.

Neville H., J. Dunham and M. Peacock. 2006. "Landscape attributes and life history variability shape genetic structure of trout populations in a stream network." *Landscape Ecology* 21:901- 916.

Nielsen, J. 1992b. "The role of cold-pool refuge in the freshwater fish assemblage in northern California rivers." Pages 79–88 in H. M. Kerner, (ed.) *Proceedings of the symposium on biodiversity of northwestern California*. Davis: University of California. Wildland Resources Center Rep. 29.

Nielsen, J. 1994. "Invasive cohorts: Impact of hatchery-reared coho salmon on the trophic, developmental, and genetic ecology of wild stocks." Pages 361–386 in D. L. Stouder, K. L. Fresh, and R. J. Feller, (eds.). *Theory and application in fish feeding ecology*. Columbia, S.C., University of South Carolina Press.

Nielsen, J. and M. Fountain. 1999. "Microsatellite diversity in sympatric reproductive ecotypes of Pacific steelhead (*Oncorhynchus mykiss*) from the Middle Fork Eel River, California." *Ecology of Freshwater Fishes*, 8, 159-168.

Nielsen, J. et al. 1998. "*Oncorhynchus* at the southern extent of their range: a study of mtDNA control-region sequence with special reference to an undescribed subspecies of *O. mykiss* from Mexico." *Environmental Biology of Fishes* 51: 7-23.

Nielsen, J. et al. 2005. "Genetics of Central Valley *O. mykiss* populations: drainage and watershed scale analyses." *San Francisco Estuary and Watershed Science*, 3.

Nielsen, J., Fountain, M. and J. Wright. 1996. "Biogeographic analysis of Pacific trout (Oncorhynchus mykiss) in California and Mexico based on mtDNA and nuclear microsatellites." *In* T. Kocher and C. Stepien (eds). *Molecular Systematics of Fishes*.

Nielsen, J., T. Lisle, and V. Ozaki. 1994. "Thermally stratified pools and their use by steelhead in northern California

streams." *Transactions of the American Fisheries Society*, 123, 613- 626.

NMFS West Coast Steelhead Biological Review Team. 2001. "Reevaluation of the Status of Klamath Mountains Province Steelhead." 35pp.

NMFS. 2005a. "Endangered and threatened species: Designation of ESA critical habitat for seven ESUs of Pacific salmon and steelhead in Washington, Oregon and Idaho." *Federal Register* (September 2, 2005), 70:52488-52627.

NMFS. 2005b. "Updated status of federally listed ESUs of West Coast salmon and steelhead." Good, T.P., R.S. Waples, and P. Adams (eds). United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Memo, NMFS-NWFSC.

NMFS. 2006a. "Endangered and threatened species: final listing determinations for 10 distinct population segments of West Coast steelhead." *Federal Register*, (January 5, 2006) 71: 834-862.

NMFS. 2006b. "Pacific Coast Salmon Recovery Fund: Report to Congress." U.S. Department of Commerce, NOAA.

NMFS. 2007a. "2007 Federal recovery outline for the Distinct Population Segment of Central California Coast Steelhead." National Marine Fisheries Service, Southwest Regional Office.

NMFS. 2007b. "2007 Federal recovery outline for the Distinct Population Segment of Northern California Steelhead." National Marine Fisheries Service, Southwest Regional Office.

NMFS. 2007c. "2007 Federal recovery outline for the Distinct Population Segment of South- Central California Coast Steelhead." National Marine Fisheries Service, Southwest Regional Office.

NMFS. 2007d. "2007 federal recovery outline for the Distinct Population Segment of Southern California Coast Steelhead." National Marine Fisheries Service, Southwest Regional Office.

NMFS. 2014. "Recovery Plan for Central Valley Chinook Salmon and Steelhead: Appendix A – Central Valley Watershed Profiles." 231pp. Web:
http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/dom
ains/california_central_valley/appendix_a_watershed_profiles_7102014.pdf.

NMFS. 2016. "2016 5-Year Review: Summary & Evaluation of Central California Coast Steelhead." 55pp. Web:
http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/201 6_ccc-steelhead.pdf.

NMFS. 2016. "Final Coastal Multispecies Recovery Plan." National Marine Fisheries Service, West Coast Region, Santa Rosa, California. 900pp.
Web:http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/
domains/north_central_california_coast/Final%20Materials/V ol%20III/vol._iii_nc_steelhead_co
astal_multispecies_recovery_plan.pdf.

NMFS. 2016. "5-Year Review: Summary & Evaluation of California Coastal Chinook Salmon and Northern California Steelhead." National Marine Fisheries Service, West Coast Region. 61pp. Web:
http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/201 6_cc-chinook_nc-steelhd.pdf.

NMFS. 2017. "Water Operations." Web: http://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/.

NOAA. National Oceanic and Atmospheric Administration. 1973. "Precipitation-frequency atlas of the western United States, Volume XI-California." National Oceanic and Atmospheric Administration, Silver Spring, Maryland.

Northcote, T. 1992. "Migration and residency in stream salmonids -some ecological considerations and evolutionary consequences." *Nordic Journal of Freshwater Research*, 67, 5- 17.

Northcote, T. 1997b. "Potamodromy in Salmonidae-living and moving in the fast lane." *North American Journal of Fisheries Management*, 17, 1029-1045.

Ohms, H. et al. 2014. “Influence of sex, migration distance, and latitude on life history expression in steelhead and rainbow trout (*Oncorhynchus mykiss*).” *Canadian Journal of Fisheries and Aquatic Sciences* 71: 70-80.

Olson, A. and O. Dix. 1992. “Salmon, Scott, and mid-Klamath sub-basin spawning ground utilization surveys 1989/1990 and 1990/1991.” Klamath River Basin Fisheries Task Force Annual Report, 33.

Opperman, J. et al. 2005. “Influence of land use on fine sediment in salmonid spawning gravels within the Russian River basin, California.” *Canadian Journal of Fisheries and Aquatic Science*, 62, 2740-2751.

Oregon Natural Resource Council and R. Nawa. 1995. “Petition under the Endangered Species Act for Chinook salmon.” Portland, OR.

Ostberg et al. 2004. “Spatial Partitioning and Asymmetric Hybridization among Sympatric Coastal Steelhead Trout (*Oncorhynchus mykiss irideus*), Coastal Cutthroat Trout *(O. clarkii clarkii*) and Interspecific Hybrids.” *Molecular Ecology*. 13: 2773-2788.

Pacific Fishery Management Council (PFMC). 1988. “Ninth Amendment to The Fishery Management Plan for Commercial and Recreational Fisheries off the Coasts of Washington, Oregon, and California commencing in 1978.” Pacific Fishery Management Council, Portland, OR.

PSMFC. 2013. “65th Annual Report of the Pacific States Marine Fisheries Commission.” Presented to the United States Congress. 84 pp. Web: http://www.psmfc.org/wp- content/uploads/2013/09/psmfc_ar12_final_web.pdf.

PSMFC. 2017. “Regional Mark Processing Center.” Web: http://www.rmpc.org/.

Papa, R. et al. 2007. “Assessment of genetic variation between reproductive ecotypes of Klamath River steelhead reveals differentiation associated with different run-timings.” *Journal of Applied Ichthyology*, 23, 142-146.

Pascual, M. et al. 2001. “First documented case of anadromy in a population of introduced rainbow trout in Patagonia, Argentina.” *Transactions of the American Fisheries Society* 130:53- 67.

Pearse, D. 2016. “Genomic Adaptation and Conservation and Management of Life-History Variation.” Presentation for Pacific Coast Steelhead Management Conference, Pacific Grove, CA March 2016. Web: http://www.psmfc.org/steelhead/2016/Pearse_PSFMC_SteelheadMtg031516.pdf.

Pearse, D. 2016. “Saving spandrels? An Adaptive genomic variation in conservation and fisheries management.” *Journal of Fish Biology.* DOI. 10.111/jfb.131168.

Pearse, D. and C. Garza. 2015. “You Can't Unscramble an Egg: Population Genetic Structure of *Oncorhynchus mykiss* in the California Central Valley Inferred from Combined Microsatellite and Single Nucleotide Polymorphism Data.” *San Francisco Estuary and Watershed Science* 13(4): 1-17.

Pearse, D. et al. 2014. “Rapid Parallel Evolution of Standing Variation in a Single, Complex, Genomic Region is Associated with Life History in Steelhead/Rainbow Trout.” *Proceedings of the Royal Society B: Biological Sciences* 281: 2014-0012.

Pearse, D. et al. *In review*. “A Simple Genetic Basis for Individual Migratory Tendency in Rainbow Trout.” National Marine Fisheries Service, Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, California.

Pearse, D., C. Donohoe, and J. C. Garza. 2007. “Population genetics of steelhead (*Oncorhynchus mykiss*) in the Klamath River.” *Environmental Biology of Fishes*, 80, 377-388.

Pearse, D., Martinez, E., and J. Garza. 2011. “Disruption of Historical Patterns of Isolation by Distance in Coastal Steelhead.” *Conservation Genetics*. 12: 691-700.

Pearse, D., Miller, M. and A. Abadia-Cardoso. 2014. “Rapid parallel evolution of standing variation in a single, complex genomic region is associated with life history in steelhead/rainbow trout.” *Proceedings of the Royal Society*. 281:20140012.

Peel, G. T. et al. 2017. "Biodiversity redistribution under climate change: impacts on ecosystems and human well-being." *Science* 355: 1389.

Peterson, M. 2011. "Possible Decline in the Half-Pounder Life History among Trinity River Steelhead (*Oncorhynchus mykiss*)." Master's thesis presented to Humboldt State University, Arcata, CA. 92pp. Web: http://scholarworks.calstate.edu/bitstream/handle/2148/869/Thesis_Peterson_FINAL.pdf?sequen ce=1.

PFMC. 2016. "Council Announces 2016 Salmon Seasons." http://www.pcouncil.org/2016/04/41860/council-announces-2016-salmon-seasons/.

Phillis, C., et al. 2016. "Shifting Thresholds: Rapid Evolution of Migratory Life Histories in Steelhead/Rainbow Trout, *Oncorhynchus mykiss*." Journal of Heredity. Doi: 10.1093/jhered/esv085. pp 51.60.

Pierce, D. et al. 2008. "Attribution of declining western U.S. snowpack to human effects." *Journal of Climate* 21: 6425-6444.

Platts, W. 1979. "Livestock grazing and riparian/ stream ecosystems-an overview." 39-45 in O. B. Cope, editor. Proceedings of the forum—grazing and riparian/stream ecosystems. Trout Unlimited, Denver.

Potter Valley Water Organization. 2016. "Potter Valley Water Organization – Facts or Fiction." Web: http://www.pottervalleywater.org/facts-fiction.html.

Power, M. 2015. "The Thirsty Eel: Summer and Winter Flow Thresholds That Tilt the Eel River of Northwestern California from Salmon-Supporting to Cyanobacterially Degraded States." *Copeia* 103.1 (2015): 200-11.

Preston, B. L. 2006. "Risk-based reanalysis of the effects of climate change on US cold-water habitat." *Climatic Change* 76:91-119

Prince, Daniel J, Sean M O'Rourke, Tasha Q Thompson, Omar A Ali, Hanna S Lyman, Ismail K Saglam, Thomas J Hotaling, Adrian P Spidle, and Michael R Miller. 2017. "The Evolutionary Basis of Premature Migration in Pacific Salmon Highlights the Utility of Genomics for Informing Conservation." *Science Advances*, August.

Puckett, L. 1972. "Sport Fisheries of the Eel River, 1972-1973." Memorandum Report. Sacramento CA, California Department of Fish and Game: 29 pp.

Puckett, L. 1975. "The status of spring-run steelhead (*Salmo gairdneri*) of the Eel River system." California Department of Fish and Game. 22 pp.

Quinn, T. 2005. "The Behavior and Ecology of Pacific Salmon and Trout." *American Fisheries Society.* 388 pp.

Quinones et al. 2014. "Dam Removal and Anadromous Salmonid (*Oncorhynchus spp.*) Conservation in California." *Reviews in Fish Biology and Fisheries* 25:195-215.

Quinones, R. and T. Mulligan. 2005. "Habitat Use by Juvenile Salmonids in the Smith River Estuary, California." *Transactions of the American Fisheries Society* 134(5): 1147-1158.

Quinones, R. et al. 2013. "Hatchery Practices may Result in Replacement of Wild Salmonids: Adult Trends in the Klamath Basin, California." *Environmental Biology of Fishes.* 97:233–246.

Quinones, R. et al. 2014. "Potential Factors Affecting Survival Differ by Run-Timing and Location: Linear Mixed-Effects Models of Pacific Salmonids (*Oncorhynchus* spp.) in the Klamath River, California." *PLoS ONE* 9(5): e98392. doi:10.1371/journal.pone.0098392.

Railsback, S. 1999. "Movement rules for spatially explicit individual-based models of stream fish." *Ecological Modeling*, 123, 73-89.

Redwood National Park. 2001. "2001 RNSP Redwood Creek Summer Steelhead Trout Survey." July 31 – August 8, 2001. 12pp. Web: http://docs.streamnetlibrary.org/StreamNet_References/CAsn90569.pdf.

Reisenbichler, R. et al. 1992. "Genetic variation in steelhead of Oregon and northern California." *Transactions of the American Fisheries Society*, 121, 158-169.

Reiser, D. and T. Bjornn. 1979. "Habitat requirements of anadromous salmonids." U.S Department of Agriculture, U.S.F.S., Portland, OR.

Rhymer, J., and D. Simberloff. 1966. "Extinction by hybridization and introgression." *Annual Review of Ecology and Systematics* 27:83-109.

Richter, A. and S. Kolmes. 2005. "Maximum temperature limits for Chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest." *Reviews in Fisheries Science*, 13, 23-49.

Ricker, S. 1997. "Evaluation of salmon and steelhead spawning habitat quality in the Shasta River basin, 1997." Inland Fisheries Administrative Report 97-9.

Ricker, S. 2003. "2001-2002 Annual Report Freshwater Creek adult steelhead run- size and life history project." CDFG, Steelhead Research and Monitoring Project.

Ricker, S. 2016. "Repeat Spawning, Spawning Survival, and Reproductive Behavior of Adult Steelhead from a Small Coastal California Stream." Presentation to the Pacific Steelhead Management Conference, March 2016, Pacific Grove, CA. Web: http://www.psmfc.org/steelhead/2016/Ricker_Mar10_StlhdMngMeet.pdf.

Ricker, S., Lindke, K. and C. Thompson. 2014. "California Coastal Monitoring Program Annual Report: Results of regional spawning ground surveys and estimates of total salmonid redd construction in Mattole River, Humboldt and Mendocino Counties California, 2012." California Department of Fish and Wildlife. Arcata, CA. 32 pp. Web: http://www.mattolesalmon.org/wp- content/uploads/2015/01/MSG_Spawner_FinalReport_2012-2013.pdf.

Ricker, S., Lindke, K., and C. Anderson. 2014. "Results of regional ground surveys and estimates of total salmonid redd construction in Redwood Creek, Humboldt County, California, 2013." California Department of Fish and Wildlife.

Rizza, S. 2015. "Asymmetric Introgression between Coastal Cutthroat Trout and Steelhead: Variable Introgression by Linkage Group." Master's Thesis - Humboldt State University. Web: http://www2.humboldt.edu/cuca/documents/theses/rizzathesis.pdf.

Roedel, P. 1953. "Common fishes of the California coast." California Department of Fish and Game. *Fish Bulletin* 91.

Roelofs, T. 1983. "Current status of California summer steelhead (*Salmo gairdneri*) stocks and habitat, and recommendations for their management." Report to USDA Forest Service Region 5.

Rybock, J., H. Horton, and J. Fessler. 1975. "Use of otoliths to separate juvenile steelhead trout from juvenile rainbow trout." Fisheries Bulletin, 73, 654- 659.

Satterthwaite, W. et al. 2012. "State-Dependent Migration Timing and use of Multiple Habitat Types in Anadromous Salmonids." *Transactions of the American Fisheries Society* 141:781-794.

Scheiff, T. et al. 2016. "Fish Use of Restored Habitat in the Stream-Estuary Ecotone Habitat of Humboldt Bay." Presentation to the Salmonid Restoration Federation March 2016.

Schindler, D. et al. 2010. "Population diversity and the portfolio effect in an exploited species." Nature (465) 609-612. doi:10.1038/nature09060.

SEC. 1998. "Effects of operations on upper Eel River anadromous salmonids. Potter Valley Project Monitoring Program (FERC 77, Article 39)." Steiner Environmental Consulting. PG&E, San Ramon, CA.

Shapovalov, L. 1939. "Recommendations for management of the fisheries of the Eel River drainage basin, California." *In*: *Report of the 1938 Eel River survey,* conducted by the California Department of Fish and Game.

Shapovalov, L. 1941. "Prospectus for an Eel River Fish Management Area." *California Department of Fish and Game*: 55.

Shapovalov, L. and A. Taft. 1954. "The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*)." California Department of Fish and Game, Fish Bulletin. Technical Report 98. 305 pp.

Shapovalov, L. and W. Dill. 1950. "A checklist of the freshwater and anadromous fishes of California." California Department of Fish and Game.

Singer, G. et al. 2013. "Interannual Variation of Reach Specific Migratory Success in Sacramento River hatchery yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*)." 96(2): 363–379. doi:10.1007/s10641-012-0037-y.

Sloat, M. and A. Osterback. 2013. "Maximum stream temperature and the occurrence, abundance, and behavior of steelhead trout (*Oncorhynchus mykiss*) in a southern California stream." *Canadian Journal of Fisheries and Aquatic Sciences.* 70: 64-73.

Sloat, M. and G. Reeves. 2013. "Individual condition, standard metabolic rate, and rearing temperature influence steelhead and rainbow trout (*Oncorhynchus mykiss*) life histories." *Canadian Journal and Fisheries and Aquatic Sciences*. 71:1-11.

Sloat, M. and G. Reeves. 2014. "Demographic and phenotypic responses of juvenile steelhead trout to spatial predictability of food sources." *Ecology* 95: pp. 2423-2433.

Sloat, M., 2013. "Ecological and evolutionary patterns of freshwater maturation in Pacific and Atlantic salmonids." *Reviews in Fish Biology and Fisheries.* DOI 10.1007/s1160-014-9344-z.

Smith, G. and R. Stearley. 1989. "The classification and scientific names of rainbow and cutthroat trouts." *Fisheries*, 14, 4-10.

Smith, J. and H. Li. 1983. "Energetic factors influencing foraging tactics of juvenile steelhead trout, *Salmo gairdneri*." *Environmental Biology of Fishes*, 8.

Snyder, J. 1931. "Salmon of the Klamath River, California." *California Fish and Game Bulletin*, 34, 129.

Snyder, J. 1933. "Description of *Salmo seleniris,* a new California trout." *Proceedings of the California Academy of Sciences*, 20, 471-472.

Snyder, J. 1934. "A new California trout." *California Department of Fish and Game*.

Sogard, S., Williams, T. and H. Fish. 2009. "Seasonal patterns of abundance, growth, and site fidelity of juvenile steelhead (*Oncorhynchus mykiss*) in a small coastal California stream." *Transactions of the American Fisheries Society* 138:549–563.

Sparkman, M. et al. 2016. "Lower Redwood Creek juvenile salmonid (smolt) abundance project, study year 2015: a report to the Fisheries Restoration Grants Program (Project No. P1210322)." CDFW AFRAMP, study 2a7: 85 p.

Sparkman, M. 2003. "Recreational angler use and catch in the Mad River, Humboldt County, California, November 2002-March 2003." California Department of Fish and Game Anadromous Fisheries Resources Assessment and Monitoring Program, Project 1g2, 32 pp.

Sparkman, M. 2015. "Upper Redwood Creek juvenile salmonid (smolt) abundance project, study year 2014." CDFG AFRAMP, 2a5: 73 p. Web: https://www.researchgate.net/publication/275650065_Upper_Redwood_Creek_Juvenile_Salmon id_Smolt_Abundance_Project_YR_2014.

Sparkman, M. 2016. "CDFW Prairie Creek, California Rotary Screw Trap Data, 2011–2015."

Sparkman, M. 2016. "Changes in Production of One and Two Year Old Steelhead Trout Smolts during Drought Conditions in a Northern California Stream." Presentation to the Pacific Steelhead Management Conference, March 2016, Pacific Grove, CA. Web: http://www.psmfc.org/steelhead/2016/SPARKMANProduction_of_one_year_old_and_two_SH_ Smolts_RC_FINAL_new_version_ppt_very_latest.pdf.

Sparkman, M. et al. 2015. “Prairie Creek Monitoring Project, 2014 Season: a report to the Fisheries Restoration Grants Program (Project No. P1210321).” Web: https://www.researchgate.net/publication/277010548_Prairie_Creek_Monitoring_Project_2014_ Season.

Sparkman, M., Duffy, W. and T. Moore. 2014. “Prairie Creek Monitoring Project, 2011-2013 Seasons: a report to the Fisheries Restoration Grants Program (Project No. P01010302).” Web: https://www.researchgate.net/publication/270274816_Prairie_Creek_Monitoring_Project_2011-2013_Seasons_a_report_to_the_Fisheries_Restoration_Grants_Program_Project_No_P01010302 .

Sparkman, S. 2016. “Changes in Production of One and Two Year Old Steelhead Trout Smolts during Drought Conditions in a Northern California Stream.” Presentation to the Pacific Steelhead Management Conference, March 2016, Pacific Grove, CA. Web: http://www.psmfc.org/steelhead/2016/SPARKMANProduction_of_one_year_old_and_two_SH_Smolts_RC_FINAL_new_version_ppt_very_latest.pdf.

Spence, B. 2007. “A framework for assessing the viability of threatened and endangered salmon and steelhead in North-Central California Coast Recovery Domain.” National Marine Fisheries Service, Southwest Fisheries Science Center, Draft June 14, 2007. 118 pp. Spence, B. et al. 1996. “An ecosystem approach to salmonid conservation.” TR-4501-96-6057.

Spence, B., and T. Williams. 2011. “Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Central California Coast Coho Salmon ESU.” NOAA-TM-NMFS-SWFSC-475. NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA. Web: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/swfsc_5_year_status_review_report_2011.pdf.

Spina, A. 2003. “Habitat associations of steelhead trout near the southern extent of their range.” *California Fish and Game* 89: 81-95.

Spina, A. 2007. “Thermal ecology of juvenile steelhead in a warm-water environment.” *Environmental Biology of Fishes*, DOI 10.1007/s10641-006-9103-7.

Spina, A. and D. Tormey. 2000. “Post-fire sediment deposition in a geographically restricted steelhead habitat.” *North American Journal Fishery Management*. 20:562-569.

Spina, A., M. Allen, and M. Clarke. 2005. “Downstream migration, rearing abundance, and pool habitat association of juvenile steelhead in the lower main stem of a South-Central California stream.” *North American Journal of Fisheries Management*, 25, 919-930.

Stephens, M. 2007. “Systematics, Genetics, and Conservation of Golden Trout.” Doctoral Dissertation. University of California Davis, Davis.

Stephens, M. 2007. “Contribution of population genetic structure, hybridization, and cultural attitudes to the conservation of threatened native trout.” PhD Dissertation. Davis, University of California.

Stephens, M. and B. May. 2010. “Final Report: Genetic Analysis of California Native Trout (Phase 2).” Report to California Department of Fish and Game. Genomic Variation Laboratory, University of California, Davis. 24 pp.

Stephens, M. and B. May. 2011. “Genetic Analysis of California Native Trout.” (Phase 4): Final Report to California Department of Fish and Game, Agreement #P0982022. Genomic Variation Laboratory, University of California, Davis. December 15, 2011. 34pp.

Stephens, M. et al. 2011. “Genetic Analysis of California Native Trout (Phase 3).” Final Report to the California Department of Fish and Game. UC Davis Genomic Variation Laboratory Publication. 47pp.

Stewart, I. et al. 2005. “Changes toward earlier streamflow timing across Western North America.” *Journal of Climate* 18: 1136-1156.

Stillwater Sciences. 2010. “Mad River Watershed Assessment.” Prepared for Redwood Community Action Agency. 169pp. Web: http://www.mrdb.naturalresourcesservices.org/BASINREFS/LOWERMAD/GravelExtraction-

related/Mad%20River%20watershed%20assessment%202010%20Final%20report.pdf.

Sugihara, N. (ed.). 2006. *Fire in California's Ecosystems*. The University of California Press. Berkeley, CA. 612pp.

Taylor, G. and Barnhart, R. 2010. "Mortality of Angler Caught and Released Summer Steelhead." Report for the California Cooperative Fisheries Research Unit and Humboldt State University Foundation. CDFG Steelhead Trout Catch Report and Restoration Card Grant Program, Contract No. FG 5018 IF. 31pp. Web: http://www2.humboldt.edu/cuca/documents/publications/Taylor&BarnhartSteelhead.pdf.

Taylor, S. 1978. "The status of salmon populations in California coastal rivers." 13 pp. Salmon/ steelhead program, Anadromous Fisheries Branch. Sacramento, CA.

Teel, D. et al. 2000. "Genetic population structure and origin of life history types in Chinook salmon in British Columbia, Canada." *Transactions of the American Fisheries Society* 129:194- 209.

Thompson, L. 2012. "Water management adaptations to prevent loss of spring-run Chinook salmon in California under climate change." *Journal of Water Resources Planning and Management* 138: 465-478.

Thompson, L. et al. 2008. "Role of hardwood in forming habitat for southern California steelhead." Pages 307-319 in A. Merenlender, D. McCreary, and K.L. Purcell, eds. *Proceedings of the Sixth California Oak Symposium: Today's challenges, tomorrow's opportunities*. USDA Forest Service General Technical Report PSW-GTR-217. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Thompson, L. et al. 2011. "Water Management Adaptations to Prevent Loss of Spring-Run Chinook Salmon in California under Climate Change." *Journal of Water Resources Planning and Management* 138(5): 465-478.

Thompson, L. et al. 2012. "Southern steelhead (*Oncorhynchus mykiss*), hard woody debris, and temperature in a California central coast watershed." *Transactions of the American Fisheries Society* 141: 275-284.

Thompson, Tasha Q, Renee M Bellinger, Sean M O'Rourke, Daniel J Prince, Alexander E Stevenson, Antonia T Rodrigues, Matthew R Sloat, Camilla F Speller, Dongya Y Yang, Virginia L Butler, Michael A Banks, Michael R Miller. 2018. Anthropogenic habitat alteration leads to rapid loss of adaptive ariation and restoration potential in wild salmon populations. bioRxiv. https://www.biorxiv.org/content/early/2018/07/06/310714

Threader, R. and A. Houston. 1983. "Heat tolerance and resistance in juvenile rainbow trout acclimated to diurnally cycling temperatures." *Comparative Biochemical Physiology* 75: 153– 155.

Trout Unlimited. (2015). *State of the Trout: A Report on the Status and Trends of Native Trout in the United States.* Trout Unlimited, Arlington, VA.

U.S. Commission of Fish and Fisheries (USCFF). 1892. Report to the Commissioner for 1888. United States Commission of Fish and Fisheries. Washington, D.C., Government Printing Office.

USFS and U.S. Bureau of Land Management (USFS-USBLM). 1996. "North Fork Eel River Watershed Analysis." Version 1.0. 146pp.

U.S. Heritage Conservation and Recreation Service (USHCRS). 1980. "Final environmental impact statement. Proposed designation of five California rivers in the national wild and scenic rivers system." U.S. Heritage Conservation and Recreation Service. 1: 322 pp.

United States Commission of Fish and Fisheries (USCFF). 1894. "Report of the commissioner for the year ending June 30, 1892." United States Commission of Fish and Fisheries. Washington, D.C., Government Printing Office.

USFWS. 1979a. "Hoopa Valley Indian Reservation- Inventory of reservation water, fish rearing feasibility study and a review of the history and status of anadromous fishery resources of the Klamath River basin." U.S. Fish and Wildlife Service.

USFWS. 1979b. "Inventory of reservation waters, fish rearing feasibility study, and a review of the history and status of

anadromous fishery resources of the Klamath River basin." U.S. Department of Interior, USFWS 143 pp.

USFWS. 1979c. "Klamath River fisheries investigations: Progress, problems and prospects." U.S. Fish and Wildlife Service Annual Report, Arcata, California, Nov. 21, 1979, 49 pp.

USFWS. 1998. "Southern steelhead, *Oncorhynchus mykiss*, habitat suitability survey of the Santa Margarita River, San Mateo and San Onofre creeks on Marine Corps Base, Camp Pendleton." Prepared for Assistant Chief of Staff, Environmental Security, USMC. Coastal California Fish and Wildlife Office, Arcata, CA. 109 pp.

USFWS. 2001. "Juvenile salmonid monitoring on the mainstem Klamath River at Big Bar and mainstem Trinity River at Willow Creek, 1997-2000." Annual Report of the Klamath River Fisheries Assessment Program. Arcata Fish and Wildlife Office, Arcata, CA.

USFWS. 2002. "Klamath River fish die-off September 2002 causative factors of mortality." Arcata Fish and Wildlife Office. AFWO-F-02-03.

USFWS. 2011. "Little kern golden trout (*Oncorhynchus mykiss whitei*) 5-year review: summary and evaluation." Sacramento, CA.

Van Kirk, S. 2013. "Mad River References." Cultural Resources Consultation. Bayside California. 166pp.

Vigg, S., and D. Koch. 1980. "Upper lethal temperature range of Lahontan cutthroat trout in waters of different ionic concentration." *Transactions of the American Fisheries Society* 109:336-339.

Voight, H. and D. Gale. 1998. "Distribution of fish species in tributaries of the lower Klamath River: an interim report, FY 1996." Yurok Tribal Fisheries Program, Habitat Assessment and Biological Monitoring Division, Report No. 3.

Wade, A. et al. 2013. "Steelhead Vulnerability to Climate Change in the Pacific Northwest." *Journal of Applied Ecology* 50: 1093-1104. 12pp.

Wallace, M. 2006. "Juvenile salmonid use of Freshwater slough and tidal portions of Freshwater Creek, Humboldt Bay, California, 2003 Annual Report." Inland Fisheries Administrative Report 2006-04.

Wallace, M. 2010. "Natural vs. Hatchery Proportions of Juvenile Salmonids Migrating through the Klamath River Estuary and Monitor Natural and Hatchery Juvenile Salmonid Emigration from the Klamath River Basin." Federal Aid Project F-51-R. 51pp.

Walton, I. 1653. *The Compleat Angler*.

Waples et al. 2008. "Evolutionary History of Pacific Salmon in Dynamic Environments." *Evolutionary Applications* (3):189-206.

Waples, R. 1991. "Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest." *Canadian Journal of Fisheries and Aquatic Science*, 48 (Suppl. 1) 124-133.

Waples, R. 1999. "Dispelling some myths about hatcheries." *Fisheries* 24, 12-21.

Waples, R. et al. 2004. "Life-history divergence in Chinook salmon: historical contingency and parallel evolution." *Evolution*, 58, 386-403.

Waples, R. et al. 2007. "A biological framework for evaluating whether a species is threatened or endangered in a significant portion of its range." *Conservation Biology* 21:964-974.

Ward, B. et al. 1989. "Size-biased survival in steelhead trout (*Oncorhynchus mykiss*): back- calculated lengths from adults' scales compared to migrating smolts at the Keogh River, British Columbia." *Canadian Journal of Fisheries and Aquatic Sciences* 46:1853–1858.

Ward, P., T. McReynolds, and C. Garman. 2003. "Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncorhynchus*

tshawytscha, Life History Investigations 2001-2002." Prepared for CDFW. Web: https://www.fws.gov/lodi/anadromous_fish_restoration/documents/IF_Admin_Report_2004- 6.pdf.

Watters, J., S. Lema, and G. Nevitt. 2003. "Phenotype management: a new approach to habitat restoration." *Biological Conservation*, 112, 435-445.

Wenger, S. et al. 2011. "Flow regime, temperature, and biotic interactions drive differential declines of trout species under climate change." *Proceedings of the National Academy of Sciences* 108(34): 14175-14180.

West, J. 1991. "A proposed strategy to recover endemic spring-run Chinook salmon population and their habitats in the Klamath River basin." Report to the Forest Service, Pacific Southwest Region. 26 pp.

Wheaton, J., G. Pasternack, and J. Merz. 2004. "Use of habitat heterogeneity in salmonid spawning habitat rehabilitation design. Fifth International Symposium on Ecohydraulics." Madrid. Aquatic Habitats: Analysis & Restoration, 791-796.

White, J. and B. Harvey. 2007. "Winter feeding success of stream trout under different stream flow and turbidity conditions." *Transactions of the American Fisheries Society*, 37, 1187-1192.

Williams, A. et al. 2015. "Contribution of Anthropogenic Warming to California Drought During 2012–2014." *Geophysical Research Letters* 42:6819-6828.

Williams, J. 2006. "Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California." *San Francisco Estuary and Watershed Science* 4(3): 416.

Williams, J. 2006. "Historical Population Structure of Central Valley Steelhead and its Alteration by Dams." *San Francisco Estuary and Watershed Science*. 4, 1-19.

Williams, J. et al. 2007. "The conservation success index: synthesizing and communicating salmonid condition and management needs." *Fisheries* 32:477-492.

Williams, J. et al. 2009. "Potential Consequences of Climate Change to Persistence of Cutthroat Trout Populations." *North American Journal of Fisheries Management* 29: 533-548.

Williams, T. et al. 2011. "Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest." 20 May 2011, update to 5 January 2011 Report to Southwest Region National Marine Fisheries Service from Southwest Fisheries Science Center, Fisheries Ecology Division.

Williams, T. et al. 2016. "Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest." Report to National Marine Fisheries Service –West Coast Region from Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-564.170pp. Web: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/tec h_memo_esa_salmon_steelhead_viaibility-swfsc.pdf.

Williams, T., Lindley, S., Spence, B. and D. Boughton. 2011. "Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest." 106pp. Web: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/swfsc_5_ year_status_review_report_2011.pdf.

Wilzbach, P. et al. 2016. "Prairie Creek Monitoring Project, 2015 Season: A Report to the Fisheries Restoration Grants Program." Project No. P1210321, 98pp.

Winter, B. 1987. "Racial identification of juvenile summer and winter steelhead and resident rainbow trout (*Salmo gairdneri* Richardson)." California Department of Fish and Game.

Wu, J., R. Adams, and W. Boggess. 2000. "Cumulative effects and optimal targeting of conservation efforts: Steelhead trout habitat enhancement in Oregon." *American Journal of Agricultural Economics*, 82, 400-413.

Yoshiyama, R. and P. Moyle. 2010. "Historical review of Eel River Anadromous Salmonids, with Emphasis on Chinook

Salmon, Coho Salmon and Steelhead." 132pp. University of California, Davis, Center for Watershed Sciences. Davis, CA. Web: https://watershed.ucdavis.edu/files/biblio/Eel%20River%20Final%20Report%202010%20Feb% 201 (1).pdf.

Zedonis, P. 1990. "The biology of juvenile steelhead (*Oncorhynchus mykiss*) in the Mattole River estuary/lagoon." Master's thesis presented to Humboldt State University, Arcata, CA.

Zimmermann, C. and G. Reeves. 2000. "Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidences from spawning surveys and otolith microchemistry." *Canadian Journal of Fisheries & Aquatic Sciences*, 57, 2152-2162.

Zuspan, M. and M. Sparkman. 2002. "Mad River winter-run adult steelhead run-size estimate, 2000-2001 season." California Department of Fish and Game Anadromous Fisheries Resources Assessment and Monitoring Program, Project, 31pp.

State of California
Department of Fish and Wildlife

Original on file. Received
January 24, 2019, 8:20 AM

Date: January 24, 2019

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

From: Charlton H. Bonham
Director

Subject: **Evaluation of the Petition to List Northern California summer steelhead (*Oncorhynchus Mykiss Irideus*) as Endangered under the California Endangered Species Act**

The California Department of Fish and Wildlife (Department) has completed its evaluation of the Petition to list Northern California summer steelhead as an endangered species (Petition) under the California Endangered Species Act, Fish and Game Code section 2050 et seq. The California Fish and Game Commission (Commission) received the Petition from the Friends of the Eel River on September 28, 2018. Pursuant to Fish and Game Code section 2073, the Commission referred the Petition to the Department on October 8, 2018. On November 5, 2018, in accordance with Fish and Game Code section 2073.5, subdivision (b), the Department requested a 30-day extension to further analyze the Petition and complete its evaluation report. The Commission approved this request, and the due date for the petition is February 5, 2019.

The Department completed the attached Petition evaluation report pursuant to Fish and Game Code section 2073.5. (See also Cal. Code Regs., tit. 14, § 670.1, subd. (d)(1).). The Department's evaluation report delineates the categories of information required in a petition and evaluates the sufficiency of the available scientific information regarding each of the Petition components. Based upon the information contained in the petition, the Department has determined that there is sufficient scientific information available at this time to indicate that the petitioned action may be warranted. The Department recommends that the Petition be accepted and considered.

If you have any questions or need additional information, please contact Mr. Ryon Kurth, Senior Environmental Scientist (Supervisor), Fisheries Branch, at (916) 445-3181 or by email at Ryon.Kurth@wildlife.ca.gov or Mr. Kevin Shaffer, Branch Chief, Fisheries Branch, at (916) 327-8841 or by email at Kevin.Shaffer@wildlife.ca.gov.

Attachment

ec: California Department of Fish and Wildlife

Stafford Lehr, Deputy Director
Wildlife and Fisheries Division
Stafford.Lehr@wildlife.ca.gov

Chad Dibble, Deputy Director
Ecosystem Conservation Division
Chad.Dibble@wildlife.ca.gov

Wendy Bogdan, General Counsel
Office of the General Counsel
Wendy.Bogdan@wildlife.ca.gov

Tina Bartlett, Regional Manager
Northern Region
Tina.Bartlett@wildlife.ca.gov

Kevin Shaffer, Chief
Fisheries Branch
Kevin.Shaffer@wildlife.ca.gov

Rick Macedo, Chief
Habitat Conservation and Planning Branch
Richard.Macedo@wildlife.ca.gov

Lena Germinario
Office of the General Counsel
Lena.Germinario@wildlife.ca.gov

Michael Yaun, Attorney
Fish and Game Commission
Michael.Yaun@fgc.ca.gov

Tony LaBanca
Environmental Program Manager
Northern Region
Tony.LaBanca@wildlife.ca.gov

Jonathan Nelson
Environmental Program Manager
Fisheries Branch
Jonathan.Nelson@wildlife.ca.gov

Allan Renger
Senior Environmental Scientist, Supervisor
Klamath-Trinity Program, Northern Region
Allan.Renger@wildlife.ca.gov

Ryon Kurth
Senior Environmental Scientist, Supervisor
Fisheries Branch
Ryon.Kurth@wildlife.ca.gov

State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

EVALUATION OF THE PETITION FROM THE FRIENDS OF THE EEL RIVER TO LIST NORTHERN CALIFORNIA SUMMER STEELHEAD (*ONCORHYNCHUS MYKISS IRIDEUS*) AS ENDANGERED

Prepared by
California Department of Fish and Wildlife

JANUARY 2019

I. Executive Summary

The Friends of the Eel River (Petitioner) submitted a petition (Petition) to the California Fish and Game Commission (Commission) to list the Northern California summer steelhead (*Onchorhynchus mykiss irideus*) (NC summer steelhead) as endangered pursuant to the California Endangered Species Act (CESA), Fish and Game Code Section 2050 *et seq*.

The Commission referred the Petition to the California Department of Fish and Wildlife (Department) in accordance with Fish and Game Code Section 2073. (Cal. Reg. Notice Register 2017, No. 13-Z, 479.) Pursuant to Fish and Game Code Section 2073.5 and Section 670.1 of Title 14 of the California Code of Regulations, the Department has prepared this evaluation report for the Petition (Petition Evaluation). The Petition Evaluation is an evaluation of the scientific information discussed and cited in the Petition in relation to other relevant and available scientific information possessed by the Department during the evaluation period. The Department's recommendation as to whether to make NC summer steelhead a candidate for listing under CESA is based on an assessment of whether the scientific information in the Petition is sufficient under the criteria prescribed by CESA to consider listing NC summer steelhead as endangered.

After reviewing the Petition and other relevant information, the Department determined the following:

- Population Trend. The Petition contains sufficient information to indicate the overall trend for NC summer steelhead (which only occurs in California) is declining, with several populations believed to be extirpated.

- Range. The Petition contains a sufficient description of the NC summer steelhead range.

- Distribution. The Petition contains a sufficient description of the historical and recent distribution of NC summer steelhead populations, and demonstrates a reduction in their distribution due to dams and continued anthropogenic habitat degradation.

- Abundance. The Petition contains a sufficient description of what is known about historical and recent abundance of NC summer steelhead populations, indicating most populations appear to be depressed or extirpated.

- Life History. While the Petition only describes the life history characteristics of adult NC summer steelhead, it sufficiently describes the unique qualities of summer-run which render them particularly vulnerable to anthropogenic impacts and the anticipated effects of climate change.

- Kind of Habitat Necessary for Survival. The Petition contains a sufficient description of the types and conditions of habitats necessary for the survival of NC summer steelhead.

- Factors Affecting the Ability to Survive and Reproduce. The Petition contains sufficient information to suggest NC summer steelhead are adversely affected by historical habitat loss due to dams, continued anthropogenic habitat degradation, and the anticipated effects of climate change, that together threaten the species' continued survival.

- Degree and Immediacy of Threat. The Petition contains sufficient information to indicate threats to the long-term survival of NC summer steelhead will continue or potentially worsen in the future. If recent findings from Prince et al. (2017) are correct, NC summer steelhead result from a single, unique evolutionary event and it is unlikely they would re-evolve from the relatively more abundant NC winter steelhead population.

- Impacts of Existing Management. The Petition contains sufficient information to suggest that existing regulatory mechanisms and management efforts do not adequately protect NC summer steelhead from impacts that threaten their long-term survival.

- Suggestions for Future Management. The petition demonstrates there are known and developing management actions that could be beneficial to NC summer steelhead and may be implemented in the future, including NMFS's suggestion to restore access to historical habitat by removing Scott Dam, which currently blocks fish passage.

- Availability and Sources of Information. While the Petition primarily cites three citations, it contains a 30-page bibliography of available literature.

- A Detailed Distribution Map. The Petition contains a sufficiently detailed map of the historical distribution of NC summer steelhead.

The Petitioner is soliciting review for an endangered species determination of NC summer steelhead. The NC steelhead Distinct Population Segment (DPS), including NC summer steelhead is currently listed as threatened under the Federal Endangered Species Act (ESA) (65 FR 36074; 71 FR 834; 79 FR 20802). The listing includes only naturally spawned steelhead (anadromous form of *O. mykiss*) and their progeny residing below impassable barriers to migration for both summer and winter ecotypes. NMFS does not designate NC summer steelhead as a separate DPS largely because the genetic data NOAA considered in its review reinforced previous conclusions that, within a geographic area, summer and winter steelhead are more genetically similar to one another than either is to populations with similar run timing in different geographic areas (Busby et al. 1996).

However, new genetic evidence suggests that NC summer steelhead are profoundly different from NC winter steelhead and that, if lost, summer steelhead would not re-evolve from proximate winter steelhead populations. If correct, this interpretation of the genetic structure of the NC steelhead DPS could result in a new DPS determination for NC summer steelhead. The Department believes the petition may be warranted on the

basis that the summer steelhead life history ecotype is at low population abundance and has limited distribution within the Northern California DPS boundary.
The discussion below focuses on analyses of the scientific information provided in the Petition, as well as from scientific information the Department possesses, or has knowledge of, in regards to NC summer steelhead populations.
In completing its Petition Evaluation, the Department has determined the Petition provides sufficient scientific information to indicate that the petitioned action may be warranted. Therefore, the Department recommends the Commission accept the Petition for further consideration under CESA.

II. Introduction

A. Candidacy Evaluation

CESA sets forth a two-step process for listing a species as threatened or endangered. First, the Commission determines whether to designate a species as a candidate for listing by determining whether the petition provides "sufficient information to indicate that the petitioned action may be warranted." (Fish & G. Code, § 2074.2, subd. (e)(2).) If the petition is accepted for consideration, the second step requires the Department to produce within 12 months of the Commission's acceptance of the petition a peer reviewed report based upon the best scientific information available that indicates whether the petitioned action is warranted. (Fish & G. Code, § 2074.6.) The Commission, based on that report and other information in the administrative record, then determines whether the petitioned action to list the species as threatened or endangered is warranted. (Fish & G. Code, § 2075.5.)

A petition to list a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and other factors the petitioner deems relevant." (Fish & G. Code, § 2072.3; see also Cal. Code Regs., tit. 14, § 670.1, subd. (d)(1).) The range of a species for the Department's petition evaluation and recommendation is the species' California range. (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal. App. 4th 1535, 1551.)

Within 10 days of receipt of a petition, the Commission must refer the petition to the Department for evaluation. (Fish & G. Code, § 2073.) The Commission must also publish notice of receipt of the petition in the California Regulatory Notice Register. (Fish & G. Code, § 2073.3.) Within 90 days of receipt of the petition, the Department must evaluate the petition on its face and in relation to other relevant information and submit to the Commission a written evaluation report with one of the following recommendations:

- Based upon the information contained in the petition, there is not sufficient information to indicate that the petitioned action may be warranted, and the petition should be rejected; or

- Based upon the information contained in the petition, there is sufficient information to indicate that the petitioned action may be warranted, and the petition should be accepted and considered.

(Fish & G. Code, § 2073.5, subds. (a)(1), (a)(2).) The Department's candidacy recommendation to the Commission is based on an evaluation of whether or not the petition provides sufficient scientific information relevant to the petition components set forth in Fish and Game Code Section 2072.3 and the California Code of Regulations, Title 14, Section 670.1, subdivision (d)(1).

In *Center for Biological Diversity v. California Fish and Game Commission* (2008) 166 Cal. App. 4th 597, the California Court of Appeals addressed the parameters of the Commission's determination of whether a petitioned action should be accepted for consideration pursuant to Fish and Game Code Section 2074.2, subdivision (e), resulting in the species being listed as a candidate species. The court began its discussion by describing the standard for accepting a petition for consideration previously set forth in *Natural Resources Defense Council v. California Fish and Game Commission* (1994) 28 Cal. App. 4th 1104:

> As we explained in *Natural Resources Defense Council* [citation], "the term 'sufficient information' in section 2074.2 means that amount of information, when considered with the Department's written report and the comments received, that would lead a reasonable person to conclude the petitioned action may be warranted." The phrase "may be warranted" "is appropriately characterized as a 'substantial possibility that listing could occur.'" [Citation] "Substantial possibility," in turn, means something more than the one-sided "reasonable possibility" test for an environmental impact report but does not require that listing be more likely than not. [Citation]

(*Center for Biological Diversity*, *supra*, 166 Cal. App. 4th at pp. 609-10.) The court acknowledged that "the Commission is the finder of fact in the first instance in evaluating the information in the record." (*Id.* at p. 611.) However, the court clarified:

> [T]he standard, at this threshold in the listing process, requires only that a substantial possibility of listing could be found by an objective, reasonable person. The Commission is not free to choose between conflicting inferences on subordinate issues and thereafter rely upon those choices in assessing how a reasonable person would view the listing decision. Its decision turns not on rationally based doubt about listing, but on the absence of any substantial possibility that the species could be listed after the requisite review of the status of the species by the Department under [Fish and Game Code] section 2074.6.

(ibid.)

CESA defines the “species” eligible for listing to include “species or subspecies” (Fish & G. Code, §§ 2062 and 2067), and courts have held that the term “species or subspecies” includes “evolutionarily significant units.” (*Central Coast Forest Assn. v. Fish & Game Com.* (2018) 18 Cal.App.5th 1191, 1236, citing *Cal. Forestry Assn.*, *supra*, 156 Cal. App. 4th at pp. 1542 and 1549.)

B. Petition History

The Northern California steelhead Evolutionarily Significant Unit (ESU) was originally proposed for listing as threatened under the federal ESA by NOAA Fisheries in 1996 (65 FR 36074). NMFS deferred the final determination for NC steelhead until March 1998, when NMFS stated that the NC steelhead ESU did not warrant listing under the Federal ESA. In 2000, NMFS proposed to list the NC steelhead ESU as a threatened species. The listing included only naturally spawned steelhead (anadromous form of *O. mykiss*) and their progeny residing below impassable barriers to migration for both summer and winter ecotypes. NOAA did not designate NC summer steelhead as a separate ESU largely due to the fact that the most recent genetic data reinforced previous conclusions that, within a geographic area, summer and winter steelhead typically are more genetically similar to one another than either is to populations with similar run timing in different geographic areas (Busby et al. 1996; 65 FR 36074). In 2006, NOAA Fisheries re-classified the listing of the NC steelhead ESU to a DPS and reaffirmed the listing status as threatened.

On September 28, 2018, the Friends of the Eel River submitted a Petition to the Commission to list NC summer steelhead as endangered under CESA. On October 8, 2018, the Commission referred the Petition to the Department for evaluation. This Petition Evaluation report was submitted to the Commission on February 5, 2019. The Commission has not previously received a petition to list NC steelhead (summer or winter) under CESA.

The Department evaluated the scientific information presented in the Petition as well as other relevant information the Department possessed at the time of review. The Department did not receive any information from the public during the Petition Evaluation period pursuant to Fish and Game Code Section 2073.4. Pursuant to Fish and Game Code Section 2072.3 and Section 670.1, subdivision (d)(1), of Title 14 of the California Code of Regulations, the Department evaluated whether the Petition includes sufficient scientific information regarding each of the following petition components to indicate that the petitioned action may be warranted:

- Population trend;
- Range;
- Distribution;
- Abundance;

- Life history;
- Kind of habitat necessary for survival;
- Factors affecting ability to survive and reproduce;
- Degree and immediacy of threat;
- Impacts of existing management;
- Suggestions for future management;
- Availability and sources of information; and
- A detailed distribution map.

C. Overview of NC summer steelhead

In the Northern California DPS, steelhead exhibit two distinct life history types. Stream-maturing steelhead enter freshwater primarily from April through June with immature gonads and require several months to mature and spawn. Ocean-maturing steelhead enter freshwater from September through March with mature gonads and spawn shortly after. NMFS classifies these two life-history variants as two distinct reproductive ecotypes—summer (stream-maturing) and winter steelhead (ocean-maturing) (Busby et al. 1996). While summer steelhead can be distinguished from winter steelhead by run timing, maturation while in fresh water, and their preferred spawning habitat in higher-gradient habitats and small tributaries, summer and winter steelhead are more genetically similar to one another than either is to populations with similar run timing in other rivers (Busby et al. 1996; Clemento 2006).

In NC summer steelhead DPS watersheds, migration typically begins during the final high flows in spring; sometimes as early as March but more frequently April through June. In the Mad River, summer steelhead enter the river mouth in early April through July as flows allow (M. Sparkman, CDFW, pers. comm. 2016). Summer steelhead continue migrating upstream into the upper reaches of the stream and oversummer. In the warm summer months, they seek out deep thermally stratified pools with overhead cover and subsurface flow to keep cool until winter (Busby et al. 1996). Summer steelhead spawn primarily in these headwater reaches from February through April, often overlapping the period that winter adults spawn.

Newly emerged fry move out of smaller natal streams into larger tributaries soon after emerging. Like winter steelhead, most juvenile steelhead migrate downstream as two-year-olds with a small portion migrating as yearlings and three-year-olds. The downstream migration period for juveniles extends from April into July with peaks in May and June. Prior to entering the ocean juvenile steelhead undergo a physiological change, known as smoltification, which enables them to survive in saline ocean

conditions. Juvenile fish from the Middle Fork Eel River generally smolt at two years old, but some NC summer steelhead enter the ocean as smolts in their third year of life after spending at least one year in the estuary (Cannata 1998). Smolts typically emigrate from the river to the estuary or ocean between March and June.

While in the ocean, NC steelhead are believed to stay near their natal streams (Harding 2015). In coastal California, steelhead usually spend one to two years in the ocean (Busby et al. 1996). The majority of returning steelhead in the Mad River are three years old (Zuspan and Sparkman 2002; Sparkman 2003). A portion of NC summer steelhead return to the river after only two to four months in the ocean as half-pounders, analogous to the grilse or jacks in Chinook salmon.

A central premise of the Petition is that NC summer steelhead are a distinct sub-species from NC winter steelhead. Currently, the Department considers the NOAA Fisheries designation of Evolutionarily Significant Unit (ESU) when evaluating petitions for listing under CESA, and the Commission has designated genetic groups of salmonids in California based on their status as ESUs. (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal. App. 4th 1535.) NOAA Fisheries considers the NC summer steelhead ecotype as a part of the greater NC steelhead DPS. However, the Petition presents new techniques in genetic analysis and subsequent findings that may indicate separation of the NC summer steelhead from NC winter steelhead. The new methods, and conclusions derived from them, are currently being debated within the scientific community, and therefore the central premise of the Petition requires evaluation beyond the scope of the Petition Evaluation.

III. Sufficiency of Scientific Information to Indicate the Petitioned Action May Be Warranted

a. Population Trend

i. Scientific information in the Petition

The information regarding both population trends and abundance are contained in the "Population Trend" section of the Petition (p. 2). The Petition primarily references two sources to characterize the population trend and abundance of NC summer steelhead, Moyle et al. 2017 (although the reference in the petition does not list the year of this publication) and the NMFS Five Year Status Review (2016).

The Petition states that NC summer steelhead populations are experiencing a long-term decline. The data for abundance and population trends of NC summer steelhead is sparse; however, the consensus from the referenced documents indicates that most NC summer steelhead populations are small, below viability targets, and in a long-term decline. Moyle et al. 2017, estimates that there are fewer than 1,000 adults across the DPS in a given year (p. 287).

ii. Conclusion

The NC summer steelhead ecotype has declined in abundance from historical times (pre-anthropogenic influences). Currently, only the Middle Fork Eel population (one of the ten identified populations within the DPS) appears stable and relatively close, though under, the NMFS viability target for abundance. The remaining populations look as though they may be extremely depressed or extirpated.

b. Range

i. Scientific information in the Petition

The information regarding range is described on pages 3-4 of the Petition. The Petition uses a map from the NMFS Coastal Multispecies Recovery Plan (2016) to display the range of NC summer steelhead (vol. III, p.4, fig.2).

The Petition refers to other summer-run steelhead populations outside the NC steelhead DPS in need of protection, namely, summer steelhead found in the Klamath Mountain Province (KMP) DPS. The KMP steelhead DPS is adjacent to the NC steelhead DPS and ranges from the Trinity River north to the Elk River in Oregon. Through email correspondence with the Department, the Petitioner stated that they intended for its petition to be limited to NC summer steelhead, however it supported including the KMP steelhead DPS in the Petition if the Department and the Commission so desired (pers. comm. S. Greacen, Friends of the Eel River).

ii. Conclusion

The information presented is an accurate account of the range of NC summer steelhead. The Petition does not provide any of the required information of CESA listing petitions for KMP summer steelhead, other than noting that KMP summer-run are also in a long-term decline and face a high likelihood of extinction in the next fifty years. Consistent with the Petitioner's instructions in its email correspondence referenced above, the Department recommends restricting the analysis of the Petition to only NC summer steelhead.

c. Distribution

i. Scientific information in the Petition

The information regarding Distribution is described on page 4 of the Petition. There is evidence the distribution of NC summer steelhead has contracted. For example, of the ten populations identified by NMFS, the North Fork and Upper Mainstem Eel are believed to no longer support summer run. Scott Dam, on the Upper Mainstem Eel River, and Mathews Dam, on the Mad River, blocks access to historically available habitat.

ii. Conclusion

The Petition contains a sufficient description of the historical and recent distribution of NC summer steelhead populations, and demonstrated a reduction in their current distribution due to dams and continued anthropogenic habitat degradation.

d. Abundance – See "Population Trend" section above

e. Life History

i. Scientific information in the Petition

The information regarding life history is listed in pages 4-6 of the Petition. The discussion of life history focuses on differences between summer and winter in adult run timing, spawning location, and a genotype. There is no discussion of juvenile rearing, smoltification, or age at maturity.

The Petition highlights a new genetic analysis that concluded a unique evolutionary event was the cause for the spatial and temporal reproductive isolation between summer and winter-run steelhead, and because summer steelhead arose from a unique evolutionary event, they are unlikely to re-evolve from proximate winter-run populations over ecological time scales. (Prince et al 2017).

The information provided does demonstrate that there is life history differentiation between summer and winter steelhead ecotypes within the NC steelhead range, including potentially important genetic differences. However, this new genetic information is being deliberated in the scientific community and has not been universally accepted. There is also uncertainty in the scientific literature regarding the use of trait-specific genomic data to define species (Waples 2018).

The Petition also emphasizes the unique life history of NC summer steelhead makes them more susceptible to climate change primarily due to higher summer water temperatures and lower discharge. The petition also contains some un-substantiated statements about an inherently greater vulnerability to predation and disease in freshwater compared to winter steelhead.

ii. Conclusion

The information provided does demonstrate that there is life history differentiation between summer and winter steelhead ecotypes within the NC steelhead range. The NC summer steelhead life history variant has declined in abundance from historical estimates.

f. Kind of Habitat Necessary for Survival

i. Scientific information in the petition

The information regarding necessary habitat is found in pages 6-10 of the Petition. The Petition presents the "Habitat Requirement" excerpt for NC summer steelhead (p. 273) found in Moyle et al (2017).

Summer steelhead require suitable coldwater habitat to over-summer while they mature. Streamflow must also be adequate for migrating steelhead to access holding habitat in the upper reaches of the watersheds they inhabit. Suitable gravel is necessary for spawning and incubation of embryos, and rearing juvenile steelhead require cool, clear, fast-flowing water.

Within this section, the Petitioner also describes the continuing degradation of habitat found within the range of NC summer steelhead. It provides a summary from Moyle et al (2017) of 15 major anthropogenic factors limiting population viability, and includes a discussion of the anticipated impacts on habitat due to climate change (NMFS 2016b). Anthropogenic effects include the following: major dams, agricultural practices, estuarine alteration, development, and hatcheries. The Petition also discusses the anticipated effects of climate change which threatens the quality and quantity NC summer steelhead habitat primarily through altered streamlflows and warmer temperatures.

ii. Conclusion

The information provided adequately describes the kind of habitat necessary for survival of all life stages of NC steelhead.

g. Factors Affecting the Ability to Survive and Reproduce

i. Scientific information in the Petition

The information regarding these factors is presented in pages 10-11 of the Petition. The Petitioner largely refers to its discussion of the impacts of habitat degradation and climate change, in the previous section, as the critical factors affecting the ability of NC summer steelhead to survive and reproduce. Specifically, it lists dams, agricultural practices, estuarine alteration, development, and hatcheries as existing, ongoing threats. Climate change is expected to further limit the range of suitable habitat for NC summer steelhead. The Petitioner concludes that the combination of habitat degradation and climate change will result in the extinction of NC summer steelhead in the near future.

ii. Conclusion

The information provided in the Petition adequately describes factors affecting the ability of NC summer steelhead to survive and reproduce. Available data for NC summer steelhead suggests that the availability of suitable habitat does limit their ability to survive and reproduce. The projected effects of climate change on critical habitat features such as streamflow and water temperature could further challenge the continued existence of NC summer steelhead.

h. Degree and Immediacy of Threat

i. Scientific information in the Petition

The Petitioner refers to Moyle et al (2017), which states that NC summer steelhead have a high risk of extinction in the next 50 years. The Petitioner concludes that NC summer steelhead are subject to rapid, likely irrecoverable loss from stochastic events or human action.

ii. Conclusion

The Petition demonstrates that there could be an immediate threat to the continued existence of NC summer steelhead. Most populations within the NC summer steelhead DPS are too data deficient to estimate their extinction risk, but overall the available data suggests that most populations are either depressed or extirpated. Only the Middle Fork Eel River summer steelhead population is near, though still below, NMFS abundance targets for viability.

i. Impact of Existing Management Efforts

i. Scientific information in the Petition

The Petition lists the impact of existing management efforts on pages 11-12. The Petition refers to Moyle et al. 2017, which states that that NC summer steelhead have no special conservation status within the state of California and recommends they should be declared as either a Species of Special Concern or listed as threatened under CESA (p. 287). The Petitioner contends that the inclusion of NC summer steelhead within the NC steelhead DPS is an obstacle to their recovery and will likely lead to the extinction of summer steelhead in the region. It refers to the most recent status review where NMFS concluded summer populations within the NC steelhead DPS continue to be of significant concern (NMFS 2016a).

ii. Conclusion

NC summer steelhead are included within the NC steelhead DPS which is listed as threatened under the federal ESA, and as such, afforded protection under ESA. There is also a federal recovery plan that has identified threats to NC summer steelhead and developed actions to hasten their recovery. The Petition contends that by including NC summer steelhead within the NC steelhead DPS management agencies fail to adequately prioritize and implement recovery actions specific to NC summer steelhead recovery.

j. Suggestions for Future Management

i. Scientific information in the Petition

The Petition presents suggestions for future management on page 12. Within this section, the Petitioner does not suggest specific actions, but refers generally to known

and developing management actions presented in Moyle et al. 2017 and the NMFS recovery plan (2016). In the “Population Trend” section on page 2, the Petitioner cites NMFS’s suggestion that removing Scott Dam may help restore an additional population of NC summer steelhead to the Upper Mainstem Eel River by restoring access to historical habitat.

The Petition does not provide independent suggestions for additional management actions, but instead highlights a lack of coordination and prioritization of known and developing actions to protect summer steelhead, and concludes that the most significant step the Commission can take to protect NC summer steelhead is to list them as endangered under CESA. Presumably, the Petitioner feels there are adequate recovery actions listed within Moyle et al. (2017) and the recovery plan (NMFS 2016b).

ii. Conclusion

The petition demonstrates there are known and developing management actions that could be beneficial to NC summer steelhead and may be implemented in the future, including NMFS’s suggestion to restore access to historical habitat by removing Scott Dam, which currently blocks fish passage.
would be placed on implementing those actions specific to conserving their life history.

k. Availability and sources of information

The Petition provides a 30 page bibliography of relevant literature. However, the Petition cites primarily 3 citations.

l. A detailed distribution map

A NC summer steelhead distribution map is located on page 3 of the Petition. The map displays what NMFS has determined are the historic distributional boundaries for the two diversity strata of NC summer steelhead, which includes 10 populations (NMFS 2016b).

IV. **Recommendation to the Commission**

Pursuant to Section 2073.5 of the Fish and Game Code, the Department has evaluated the Petition on its face and in relation to other relevant information the Department possesses or received. In completing its Petition Evaluation, the Department finds there is sufficient scientific information to indicate that the petitioned action may be warranted, and recommends the Commission accept and consider the Petition.

References

65 FR 36074. 2000. Endangered and Threatened species: Threatened Status for One Steelhead Evolutionarily Significant Unit (ESU) in California. June 7, 2000. Federal Register 65:36074-36094.

71 FR 834. 2006. Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead; Final Rule. January 5, 2006. Federal Register 71: 834-861.

79 FR 20802. 2014. Endangered and Threatened Wildlife; Final Rule to Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service. May 6, 2014. Federal Register 79: 20802-20817.

Busby, P., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status Review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA. NMFS-NWFSC-27. 261 pp

Cannata, S. 1998. Observation of steelhead trout (*Oncorhynchus mykiss*), Coho salmon (*O. kisutch*) and water quality of the Navarro River estuary/lagoon May 1996 to December 1997. Humboldt State University Foundation.

Clemento, A. 2006. Subpopulation structure of steelhead trout (*Oncorhynchus mykiss*) in the Middle Fork Eel River as determined by microsatellite DNA polymorphism. Humboldt State University

Sparkman, M. 2003. Recreational angler use and catch in the Mad River, Humboldt County, California, November 2002-March 2003. California Department of Fish and Game Anadromous Fisheries Resources Assessment and Monitoring Program, Project 1g2, 32 pp.

Moyle, Peter, Lusardi, Robert A, Samuel, Patrick J, Katz, Jacob V. E. 2017. *State of the Salmonids: Status of California's Emblematic Fishes 2017.* UC Davis Watershed Sciences Center. A report commissioned by California Trout (August 2017). 579 pp

NMFS. 2016a. 2016 5-Year Review: Summary & Evaluation of California Coastal Chinook Salmon and Northern California Steelhead. April 2016. Web: https://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/2016_cc-chinook_nc-steelhd.pdf

NMFS. 2016b. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California. October 2016. Web: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/index.html

Prince, Daniel J, Sean M O'Rourke, Tasha Q Thompson, Omar A Ali, Hanna S Lyman, Ismail K Saglam, Thomas J Hotaling, Adrian P Spidle, and Michael R Miller. 2017. The Evolutionary Basis of Premature Migration in Pacific Salmon Highlights the Utility of Genomics for Informing Conservation. Science Advances. 2017(3): e1603198.

Waples, Robin S., Steven T. Lindley. 2018. Genomics and conservation units: The genetic basis of adult migration timing in Pacific salmonids. Evolutionary Applications 2018;1-9

Zuspan, M. and M. Sparkman. 2002. Mad River winter-run adult steelhead run-size estimate, 2000-2001 season. California Department of Fish and Game Anadromous Fisheries Resources Assessment and Monitoring Program. 31pp.