National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Consultation on the Issuance of Twelve ESA Section 10 (a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Eulachon and Green Sturgeon in Californian

NMFS Consultation Number: WCR-2018-9540
ARN: 151422WCR2018PR00089

Action Agencies: The National Marine Fisheries Service (NMFS)
U.S. Fish and Wildlife Service (FWS)

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Sacramento River winter-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
California Coastal Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Southern Oregon/Northern California Coast coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Central California Coast coho salmon (*O. kisutch*)	Endangered	Yes	No	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Northern California steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
South-Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern California steelhead (*O. mykiss*)	Endangered	Yes	No	No	No
Southern green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Southern eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Southern Resident killer whales (*Orcinus orca*)	Endangered	No	No	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

for Barry A. Thom
Regional Administrator

Date: September 5, 2018

cc: Administrative record number: 151422WCR2018PR00089

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1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402. It constitutes a review of twelve scientific research permits proposed for issuance by NMFS under section 10(a)(1)(A) of the ESA and is based on information provided in the associated applications for the proposed permits, published and unpublished scientific information on the biology and ecology of listed salmonids and eulachon in the action areas, and other sources of information.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System [https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts]. A complete record of this consultation is on file with the Protected Resources Division in the Portland, Oregon office of NMFS's West Coast Region: 1201 NE Lloyd Blvd, Portland, Oregon 97232.

1.2 Consultation History

The West Coast Region's Protected Resources Division (PRD) received twelve applications for permits to conduct scientific (Table 1). Seven applications were renewals of existing permits and five applications were new permits. Because the permit requests are similar in nature and duration and are largely expected to affect the same listed species, we combined them into a single consultation pursuant to 50 CFR 402.14(c). Five of the applications are for entirely new work and the other seven applications are permit renewals for permits that have previously been approved. As noted on the cover page, the affected species are Central Valley spring-run (CVSR) Chinook salmon, Sacramento River winter-run (SRWR) Chinook salmon, California Coastal (CC) Chinook salmon, Southern Oregon/Northern California Coast (SONCC) coho salmon, Central California Coast (CCC) coho salmon, California Central Valley (CCV) steelhead, Northern California (NC) steelhead, CCC steelhead, South-Central California Coast (S-CCC) steelhead, Southern California (SC) steelhead, and southern Distinct Population Segment (sDPS) green sturgeon, and sDPS eulachon.

Because they may affect listed Chinook salmon, the proposed research activities also have the potential to affect Southern Resident (SR) killer whales and their critical habitat by diminishing the whales' prey base. However, we concluded that because the proposed activities would have such an insignificant effect on that prey base, they were not likely—even in combination—to adversely affect SR killer whales or their critical habitat. The full analysis for this conclusion is found in the "Not Likely to Adversely Affect" determination section (2.11).

Permit applications were submitted between September 8, 2016 and October 27, 2017. After coordinating with the applicants, the updated applications were determined to be complete. A Notice of Receipt for all twelve permit applications was published in the *Federal Register* asking for public comment on the applications—83 FR 11505 (March 15, 2018). All of this took place after a period of pre-consultation. The public was given 30 days to comment on the applications. The public comment period ended on April 16, 2018, and no public comments were received so once the comment period closed, we initiated consultation on April 16, 2018. The full consultation histories for the twelve actions are not directly relevant to this analysis and so are not detailed here. That history is documented in the docket for this consultation, which is maintained by the Protected Resource Division in Portland, Oregon.

Table 1. The Applications (and their Associated Applicants) Considered in this Biological Opinion.

Permit Number	*Applicant*
1606-2R	Zack Larson and Associates
15573-3R	Glenn-Colusa Irrigation District
15730-2R	Salmon Protection and Watershed Network
15824-2R	County of Santa Cruz
16110-2R	Marin Municipal Water District
16417-2R	Santa Clara Valley Water District
16544	California Department of Fish and Wildlife
17428-3R	U.S. Fish and Wildlife Service
20622	Confluence Environmental Company
20792	FISHBIO
21499	California Department of Water Resources
21547	California Department of Fish and Wildlife

1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). When an analyzing the effects of the action, we also consider the effects of other activities that are interrelated or interdependent with the proposed action. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). In this instance, we found no actions that are interrelated to or interdependent with the proposed research actions. In the absence of any such actions, the proposed action here is NMFS's proposal to issue scientific research permits pursuant to section 10(a)(1)(A) of the ESA to the twelve applicants.

The permits would authorize researchers to take threatened CVSR Chinook salmon, endangered SRWR Chinook salmon, threatened CC Chinook salmon, threatened SONCC coho salmon, endangered CCC coho salmon, threatened CCV steelhead, threatened CCC steelhead, threatened NC steelhead, threatened S-CCC steelhead, endangered SC steelhead, threatened sDPS green sturgeon and threatened sDPS eulachon. "Take" is defined in section 3 of the ESA; it means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect [a listed species] or to attempt to engage in any such conduct.

Permit 1606-2R

Zach Larson and Associates is seeking to renew for five years a research permit that currently allows them to take juvenile SONCC coho in the Smith River, Morrison Creek, Ranch Bar, Saxton Bar Alcove, and Yontocket Slough in Northern California. The research may also cause them to take adult eulachon—a species for which there are currently no ESA take prohibitions. The study's purpose is to establish baseline data for the comparability between pre-treatment and post-treatment project sites. Documenting salmonid and non-salmonid species presence and their habitat use in privately owned portions of the Smith River is also needed to identify further habitat enhancement opportunities in the Smith River. This research would benefit the affected species by informing future restoration designs, providing data to support future enhancement projects, and helping managers assess the status of salmonid populations in the sloughs and alcoves in the Smith River estuary. The researchers propose to capture fish using beach seines. Captured fish would be captured, handled, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 15573-3R

The Glenn-Colusa Irrigation District (GCID) is seeking to renew for five years a research permit that currently allows them to take juvenile CVSR chinook, SRWR chinook, CCV steelhead and juvenile green sturgeon in the Sacramento River, California. The study's purpose is to monitor restoration actions and to detect annular and cyclic population changes. The GCID project provides the longest and most complete anadromous fish data set on Sacramento River. The research would benefit the affected species by informing operational decisions for state and Federal water facilities and supplementing other monitoring projects conducted in the Sacramento River Basin. The researchers propose to use a rotary screw trap to capture the targeted fish. Fish would be anesthetized, identified to species, measured, tissue sampled for genetic analysis (fin clip and scales), and allowed to recover before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 15730-2R

The Salmon Protection and Watershed Network (SPAWN) is seeking to renew for five years a research permit that currently allows them to take spawned adult carcasses and juvenile CCC coho, CC Chinook and CCC steelhead in Lagunitas Creek and its tributaries, in Marin County, California. The study's purpose is to provide baseline data on habitat and juvenile and adult salmon abundance throughout the species' range for CCC Coho. The research would benefit the affected species by providing data to inform future research, restoration, and conservation efforts. The researchers propose to use fyke nets to capture juvenile fish and observe adult fish during spawning surveys. Captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 15824-2R

The County of Santa Cruz is seeking to renew for five years a research permit that currently allows them to take juvenile CCC coho, CCC steelhead, and S-CCC steelhead in the San Lorenzo River and its tributaries, Aptos Creek and its tributaries, Corralitos Creek and its tributaries, and Soquel Creek and its tributaries. The study's purpose is to document habitat conditions and collect data on juvenile salmonid abundance in Santa Cruz County watersheds. The research would benefit the affected species by providing data on salmonid spawning and rearing habitat conditions and thereby help inform habitat restoration and conservation efforts and land and water use decisions. The researchers at Santa Cruz County propose to use backpack electrofishing and beach seines to capture fish and to observe fish during snorkel surveys. Captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16110-2R

The Marin Municipal Water District (MMWD) is seeking to renew for five years a research permit that currently allows them to take juvenile and adult CCC coho, CCC steelhead, and CC Chinook in Lagunitas Creek (including two tributaries, San Geronimo Creek and Devil's Gulch) and Walker Creek. The study's purpose is to document trends in coho salmon abundance, determine freshwater and marine survival rates for coho salmon, assess the relationship between population trends and management efforts, and determine which coho life stage has the lowest survival rates. In Lagunitas Creek, this research would benefit the affected species by providing a consistent sampling program as a standardized method to evaluate salmon populations. The renewed monitoring program would maintain Lagunitas Creek as a Coastal Monitoring Program (CMP) life-cycle monitoring station. In Walker Creek, the research would benefit the affected species by providing needed population data for coho and steelhead—data needed to inform future habitat restoration. The MMWD propose to use backpack electrofishing and rotatory screw traps to capture fish and to observe fish during snorkel surveys and spawning surveys. Captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16417-2R

The Santa Clara Valley Water District (SCVWD) is seeking to renew for five years a research permit that currently allows them take of juvenile and adult CCC steelhead in Guadalupe Creek, Alamitos Creek, Calero Creek, Los Gatos Creek, Guadalupe River, Stevens Creek, Coyote Creek, Upper Penitencia Creek, and Lake Almaden. The study's purpose is to collect baseline data on *O. mykiss* population status, survival rates and migration patterns. This research would benefit the affected species by filling in data gaps on *O. mykiss* distribution and habitat use in Santa Clara County. The SCVWD proposes to use backpack and boat electrofishing to capture fish. The researchers would also use Vaki Riverwatchers, underwater infrared fish counters, at existing facilities to document migration. All captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16544

The California Department of Fish and Wildlife (CDFW) is seeking a five-year permit to annually take juvenile and adult SC steelhead in Southern California from Topanga Canyon to Santa Maria. The purpose of this project is to monitor the population status, trends, spatial structure, and life history diversity of SC steelhead. This research would benefit the affected species by providing information to manage and recover the species. The CDFW proposes to use backpack electrofishing, hand and/or dipnets, beach seines, hook and line sampling, minnow traps, fyke nets, and weirs to capture fish. Fish would also be observed during snorkel and spawning surveys. Captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover in cool, aerated water before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 17428-3R

The U.S. Fish and Wildlife Service (USFWS) is seeking to renew for five years a research permit that currently allows them take juvenile CVSR Chinook, SRWR Chinook, and juvenile and adult CCC steelhead on the America River, CA. The study's purpose is to monitor the abundance of juvenile salmon, infer biological responses to ongoing habitat restoration activities, and generate data for the salmon life cycle models. The research would benefit the affected species by informing future efforts to enhance the juvenile salmonid abundance, production, condition, and survival in the American River. The USFWS propose to use a rotary screw trap to capture fish. Captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 20622

The Confluence Environmental Company (CEC) is seeking a five-year permit to annually take juvenile CC Chinook, juvenile SONCC coho, juvenile NC steelhead, subadult green sturgeon and adult eulachon—a species for which there are currently no ESA take prohibitions—in Humbolt Bay, CA. The study's purpose is to compare different fish communities using estuarine habitats with and without oyster aquaculture in Humboldt Bay. The research would benefit the affected species by providing information on the environmental impacts shellfish aquaculture may have on the listed animals. The CEC proposes to use fyke nets to capture fish. Captured fish would be identified to species, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 20792

FISHBIO is seeking a five-year permit to annually take juvenile and adult CCV steelhead, CVSR Chinook, and sDPS green sturgeon in the San Joaquin River and San Joaquin's river south delta. The study's purpose is to characterize the spatial distribution of non-native resident fishes in the San Joaquin River and delta, and to identify areas of relatively elevated predator abundance. That information, in turn, would benefit listed species by increasing our understanding of the potential impacts predators may be having on juvenile salmonids migrating through this region and thus helping inform management decisions. FISHBIO proposes to use boat electrofishing to capture fish and to observe fish during stream surveys. Captured fish would be immediately placed in an aerated livebox until processing (i.e., measuring and recording) is complete, and a partition in the livebox would separate potential predators from prey-sized fish to eliminate harmful interactions. Captured fish would be identified to species, and released. ESA-listed fish would be kept for as little time as possible and released before non-listed species. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 21499

The California Department of Water Resources (DWR) is seeking a five-year permit to annually take juvenile SRWR Chinook, CVSR Chinook, CCV steelhead and sDPS green sturgeon in the Northern Sacramento River Delta. The purpose of this project is test if the removal or reduction of invasive aquatic vegetation biomass changes the density and composition of the local food web. The research would benefit the affected species by providing information on ways to reduce non-native predator numbers and helping direct habitat restoration for native fish. The DWR proposes to use boat electrofishing to capture fish. Captured fish would be identified to species, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 21547

The CDFW is seeking a two-year permit to take juvenile SONCC coho, CC Chinook, NC steelhead, CCV steelhead, CCC coho, CVSR Chinook, SRWR Chinook, CCC steelhead, SC steelhead, and sDPS green sturgeon. The study's purpose is to assess the condition of the rivers and streams in California and provide a baseline for future comparisons. CDFW is participating in the USEPA National Rivers and Streams Assessment (NRSA), a probability-based survey designed to assess the condition of the Nation's rivers and streams. NRSA is a keystone program in California that provides data for the National Water Quality Inventory Report to Congress (305(b) report) and fulfills the water quality criteria and water quality monitoring requirements of the Clean Water Act. The CDFW proposes to capture fish by boat, raft or backpack electrofishing. Captured fish would be identified and measured. After the captured fish have fully recovered in an aerated live well they would be released at or near the location of capture, away from any future electroshocking activities. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Common Elements among the Proposed Permits

Research permits lay out the conditions to be followed before, during, and after the research activities are conducted. These conditions are intended to (a) manage the interaction between scientists and listed salmonids by requiring that research activities be coordinated among permit holders, and between permit holders and NMFS, (b) minimize impacts on listed species, and (c) ensure that NMFS receives information about the effects the permitted activities have on the species concerned. All research permits we issue have the following conditions:

1. The permit holder must ensure that listed species are taken only at the levels, by the means, in the areas and for the purposes stated in the permit application, and according to the conditions in this permit.

2. The permit holder must not intentionally kill or cause to be killed any listed species unless the permit specifically allows intentional lethal take.

3. The permit holder must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the permit holder must process listed fish first to minimize handling stress.

4. Each researcher must stop capturing and handling listed fish if the water temperature exceeds 70 °F (21.1 °C) at the capture site. Under these conditions, listed fish may only be identified and counted. Additionally, electrofishing is not permitted if water temperatures exceed 64 °F (17.8 °C).

5. If the permit holder anesthetizes listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

6. The permit holder must use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

7. If the permit holder unintentionally captures any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be

reported.

8. The permit holder must exercise care during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning. Researchers must avoid walking in salmon streams whenever possible, especially where listed salmonids are likely to spawn. Visual observation must be used instead of intrusive sampling methods, especially when just determining fish presence.

9. The permit holder using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (June 2000) available at http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.

10. The permit holder must obtain approval from NMFS before changing sampling locations or research protocols.

11. The permit holder must notify NMFS as soon as possible but no later than two days after any authorized level of take is exceeded or if such an event is likely. The permit holder must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

12. The permit holder is responsible for any biological samples collected from listed species as long as they are used for research purposes. The permit holder may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

13. The person(s) actually doing the research must carry a copy of this permit while conducting the authorized activities.

14. The permit holder must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

15. The permit holder must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

16. The permit holder may not transfer or assign this permit to any other person as defined in Section 3(12) of the ESA. This permit ceases to be in effect if transferred or assigned to any other person without NMFS' authorization.

17. NMFS may amend the provisions of this permit after giving the permit holder reasonable notice of the amendment.

18. The permit holder must obtain all other Federal, state, and local permits/authorizations needed for the research activities.

19. On or before January 31st of every year, the permit holder must submit to NMFS a

post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results. The report must be submitted electronically on our permit website, and the forms can be found at https://apps.nmfs.noaa.gov/. Falsifying annual reports or permit records is a violation of this permit.

20. If the permit holder violates any permit condition they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA section 10(d) findings are no longer valid.

21. If any listed juvenile fish are unintentionally killed during these activities they must be used in place of intentional mortalities.

"Permit holder" means the permit holder or any employee, contractor, or agent of the permit holder. Also, NMFS may include conditions specific to the proposed research in certain permits.

NMFS uses annual reports for each permit to monitor the actual number of listed fish taken annually in the scientific research activities and will adjust permitted take levels if they are deemed to be excessive or if cumulative take levels rise to the point where they are detrimental to the listed species.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an Incidental Take Statement that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

The analysis here therefore examines the take that may affect the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this opinion. The NMFS determined that the proposed action of issuing twelve scientific research permits, individually or in aggregate:

- May adversely affect CVSR Chinook salmon, SRWR Chinook salmon, CC Chinook salmon, SONCC coho salmon, CCC coho salmon, CCV steelhead, CCC steelhead, NC steelhead, S-CCC steelhead, SC steelhead, sDPS green sturgeon, and sDPS eulachon, but would not jeopardize their continued existence.

- Is not likely to adversely affect SR killer whales or critical habitat designated for any of the subject species.

The reason for our determinations is presented below.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214). The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat.

The designation(s) of critical habitat for species use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

Section 4(d) protective regulations prohibit taking naturally spawned fish and listed hatchery fish with an intact adipose fin but do not prohibit taking listed hatchery fish that have had their adipose fins removed (70 FR 37160, 71 FR 834). As a result, researchers do not require a permit to take hatchery fish that have had their adipose fin removed. Nevertheless, this document evaluates impacts on both natural and hatchery fish to determine the effects of the action on each species as a whole.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach. For research actions, exposure equates to capturing and handling the animals (including tagging, etc.); response is the degree to which they are affected by the actions (e.g., injured or killed); and risk relates to what those responses mean at the individual, population, and species levels.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

The ESA defines species to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." NMFS adopted a policy for identifying salmon DPSs in 1991 (56 FR 58612). It states that a population or group of populations is considered an ESU if it is "substantially reproductively isolated from conspecific populations," and if it represents "an important component of the evolutionary legacy of the species." The policy equates an ESU with a DPS. In 1996 NMFS and the USFWS adopted a joint DPS policy, and in 2005 NMFS began applying that policy to *O. mykiss* (steelhead). Hence, CCC Chinook salmon, SRWR Chinook salmon, and CVSR Chinook salmon constitute ESUs of the species *O. tshawytscha*; SONCC coho salmon and CCC coho salmon constitute ESUs of the species *O. kisutch;* and NC steelhead, CCV steelhead, CCC steelhead, S-CCC steelhead and SC steelhead constitute DPSs of the species *O. mykiss*. These ESUs and DPSs include natural-origin populations and hatchery populations, as described in the species status sections below. Finally, the green sturgeon listing unit in this biological opinion constitute a DPS.

2.2.1 Climate Change

One factor affecting the rangewide status of the species considered here, and aquatic habitat at large is climate change. Average summer air temperatures are expected to increase in California, according to modeling of climate change impacts (Lindley et al. 2007). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe et al. 2004). Total precipitation in California may decline, critically dry years may increase (Lindley et al. 2007, Schneider 2007). The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Luers et al. 2006). Wildfires are expected to increase in frequency and magnitude, by as much as 55 percent under the medium emissions scenarios modeled (Luers et al. 2006). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal California streams under various warming scenarios is less certain, although as noted above, total rainfall across the state is expected to decline.

For the California North Coast, some models show large increases in precipitation (75 to 200 percent) while other models show decreases of 15 to 30 percent (Hayhoe et al. 2004). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures. Estuaries may also experience changes detrimental to salmonids and green sturgeon. Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia et al. 2002). In marine environments, ecosystems and habitats important to subadult and adult green sturgeon and salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely et al. 2004, Brewer 2008, Osgood 2008, Turley 2008), which would be expected to negatively affect marine growth and survival of listed fish. The projections described above are for the mid- to late-21st Century. In shorter time frames, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007, Smith et al. 2007). While in the long run climate change is expected to have a negative impact on listed fish populations, given the short time frame of the proposed research activities, climate change is not expected to have a large impact on listed fish.

The earth's oceans are also warming, with considerable interannual and inter-decadal variability superimposed on the longer-term trend (Bindoff *et al.* 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances (Scheuerell and Williams 2006; Zabel *et al.* 2006; USGCRP 2009). Ocean conditions adverse to salmon and steelhead may be more likely under a warming climate (Zabel *et al.* 2006). Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Marine fish species have exhibited negative responses to ocean acidification conditions that include changes in growth, survivorship, and behavior. Marine phytoplankton, which are the base of the food web for many oceanic species, have shown varied responses to ocean acidification that include changes in growth rate and calcification (Feely *et al.* 2012).

2.2.2 Status of Listed Species

For Pacific salmon, steelhead, eulachon and green sturgeon, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These viable salmonid population (VSP) criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

"Abundance" generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

"Productivity," as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species' populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extirpations from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

In addition to evaluating the species' viability, we will discuss the factors limiting their recovery and the threats they face. Limiting factors are the physical, biological, or chemical conditions (e.g., inadequate spawning habitat, habitat connectivity, high water temperature, competition, etc.) experienced by the fish at the population, intermediate (e.g., stratum or major population grouping), or ESU levels that result in reductions in VSP parameters (abundance, productivity, spatial structure, and diversity). Threats are the human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may be caused by the continuing results of past events and actions as well as by present and anticipated events and actions.

A species' status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species' status. The present body of scientific information on the status including the abundance, productivity, distribution, and genetic composition of anadromous salmonid populations in California is incomplete (Good et al. 2005, Spence et al. 2008, Williams et al. 2011). For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild. Information on the status and distribution of all the species considered here can be found in the following discussions and documents:

- Status review of West Coast steelhead from Washington, Idaho, Oregon, and California (Busby et al. 1996)
- Status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998)
- Updated status of Federally listed ESUs of West Coast salmon and steelhead (Good et al. 2005)
- Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (Ford 2011)
- Viability Assessment for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest (Williams et al. 2016)
- Status review update of eulachon (*Thaleichthys pacificus*) listed under the Endangered Species Act: Southern Distinct Population Segment (Gustafson et al. 2016)
- Salmon and Steelhead 2016 Status Reviews NOAA's National Marine Fisheries Service West Coast Region:
    - 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit (NMFS 2016a)
    - 5-Year Status Review: Summary and Evaluation of Sacramento River Winter-Run Chinook Salmon ESU (NMFS 2016b)
    - 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon and Northern California Steelhead (NMFS 2016c)
    - 5-Year Review: Southern Oregon/Northern California Coast Coho Salmon (NMFS 2016d)
    - 5-Year Review: Summary and Evaluation of Central California Coast Coho Salmon (NMFS 2016e)
    - 5-Year Review: Summary and Evaluation of Central Valley Steelhead Distinct Population Segment (NMFS 2016f)
    - 5-Year Review: Summary and Evaluation of Central California Coast Steelhead (NMFS 2016g)
    - 5-Year Review: Summary and Evaluation of South-Central California Coast Steelhead Distinct Population Segment (NMFS 2016h)
    - San Joaquin River Restoration: San Joaquin River Spring-Run Chinook Salmon Reintroduction (NMFS 2016i)

2.2.2.1 Central Valley Spring-run Chinook Salmon

Description and Geographic Range. CVSR Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). The listing status has been reaffirmed in three subsequent status reviews (Good et al. 2005, Williams et al. 2011, Williams et al. 2016). This ESU consists of spring-run Chinook salmon occurring in the Sacramento and San Joaquin rivers and their tributaries. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CVSR Chinook salmon ESU. The San Joaquin component of the ESU, previously extirpated, has been reintroduced and designated as a nonessential experimental population (NEP) under Section 10(j) of the ESA. Although FRFH spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibition because they are all adipose fin clipped.

In April 2016, NMFS completed a status review and concluded that CVSR Chinook salmon status should remain as previously listed (76 FR 50447). The 2016 Status Review (NMFS 2016a) stated that although the listings remained unchanged since the 2011 and 2005 review, and the original 1999 listing (64 FR 50394), the status of these populations has likely improved since the 2011 status review and the ESU's extinction risk may have decreased, however, the ESU is still facing significant extinction risk and that risk is likely to increase over the next few years as the full effects of the recent drought are realized (NMFS 2016a).

Spatial Structure and Diversity. The Central Valley Technical Review Team estimated that historically there were 18 or 19 independent populations of CVSR Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Lindley et al. 2004). Of these 18 populations, only three populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group (Table 2).

Table 2. Historical Populations of CVSR Chinook salmon (Lindley et al. 2004).

Stratum	Population [1]	Status	Comment
Southern Cascades	Little Sacramento River	*Extirpated*	Blocked by Keswick and Shasta dams
	Pit River/Fall River/Hat Creek	*Extirpated*	Blocked by Keswick and Shasta dams
	McCloud River	*Extirpated*	Blocked by Keswick and Shasta dams
	Battle Creek	*Extirpated*	Hydro operations, water diversions
	Mill Creek	Extant	Either two independent populations or a single panmictic population
	Deer Creek	Extant	
	Butte Creek	Extant	-
	Big Chico Creek	Intermittent	-
	Antelope Creek	Intermittent	-
Coast Range	*Clear Creek*	*Extirpated*	-
	Cottonwood / Beegum creeks	Intermittent	Beegum Creek intermittent, Cottonwood Creek extirpated
	Thomes Creek	*Extirpated*	-

Stratum	Population [1]	Status	Comment
	Stony Creek	*Extirpated*	-
Northern Sierra	West Branch Feather River	*Extirpated*	Blocked by Oroville Dam
	North Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	Middle Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	South Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	Yuba River	*Extirpated*	Blocked by Englebright Dam
	North and Middle Fork American River	*Extirpated*	Blocked by Nimbus Dam
	South Fork American River	*Extirpated*	Blocked by Nimbus Dam
Southern Sierra	Mokelumne River	*Extirpated*	Blocked by Camanche Dam
	Stanislaus River	*Extirpated*	Blocked by New Melones and Tulloch dams
	Tuolumne River	*Extirpated*	Blocked by La Grange and Don Pedro dams
	Merced River	*Extirpated*	Blocked by McSwain and New Exchequer dams
	Middle and Upper San Joaquin River	*Extirpated*	Blocked by Friant Dam
	Kings River	*Extirpated*	Blocked by dry streambeds and Pine Flat Dam

[1]Italicized populations are dependent populations

Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Lindley et al. (2007) found that the Mill Creek, Deer Creek, and Butte Creek populations were at or near low risk of extirpation. The ESU as a whole, however, could not be considered viable because there were no extant populations in the three other diversity groups. In addition, Mill, Deer and Butte creeks are close together, decreasing the independence of their extirpation risks due to catastrophic disturbance (Williams et al. 2011; NMFS 2016a).

Central Valley spring-run Chinook salmon escapement increased slightly in recent years (2012-2014), however, abundance dropped dramatically in 2015 (NMFS 2016a). Until 2015, Mill Creek and Deer Creek populations both improved from high extinction risk in 2010 to moderate extinction risk due to recent increases in abundance. Butte Creek continued to satisfy the criteria for low extinction risk. Additionally, since 1996, partly due to increased flows provided in upper Battle Creek, the CVSR Chinook salmon population began and are continuing to naturally repopulate Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the CVSR Chinook salmon population in Clear Creek has been increasing, and currently meets the moderate extinction risk score.

At the ESU level, the reintroduction of spring-run Chinook salmon to Battle Creek and increasing abundance of spring-run Chinook salmon in Clear Creek is benefiting the status of CVSR Chinook salmon. Further efforts, such as those underway to get some production in the San Joaquin River below Friant Dam and to facilitate passage above Englebright Dam on the Yuba River, will be needed to make the ESU viable (Williams et al. 2011).

Abundance and Productivity. Historically spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (CDFG 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929).

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CVSR Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations in the ESU. Generally, these streams have shown a positive escapement trend since 1995, displaying broad fluctuations in adult abundance, ranging from 4,429 in 2009 to 26,663 in 2001 (Table 3). Escapement numbers are dominated by Butte Creek returns, which averaged over 9,092 fish from 1995 to 2015 (peaking in 1998 at over 20,000 fish and then declined to only 569 in 2015). During this same period, adult returns on Mill and Deer creeks have averaged 674 and 1,076 fish total, respectively. From 2001 to 2005, the CVSR Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good et al. 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CVSR Chinook salmon remained well below estimates of historic abundance.

Table 3. CVSR Chinook salmon population estimates from CDFW (2016b) and Feather River Hatchery counts (pers. comm. 2017).

Year	Sacramento River Basin Escapement Run Size	Feather River Hatchery Fish	Feather River Naturally Produced Fish	Tributary Populations
2006	24,059	13,334	4104	10,725
2007	13,084	3,856	5,900	9,228
2008	12,736	861	1,024	11,875

2009	4,572	1,132	333	3,440
2010	6,122	3,160	342	2,962
2011	10,269	4,464	1559	5,805
2012	25,095	6,407	1058	18,688
2013	37,658	18,256	1801	19,402
2014	13,868	6,743	546	7,125
2015	6,391	5,196	159	1,195
5-year Average	18,656	8,213	1,025	10,443

From 2005 through 2011, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extirpation risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011c). Butte Creek has sufficient abundance to retain its low extirpation risk classification, but the rate of population decline in years 2006 through 2011 is nearly sufficient to classify it as a high extirpation risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extirpation include, Butte, Deer and Mill creeks (NMFS 2011c). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. Year 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers combined for Butte, Mill and Deer creeks increased (over 17,000), which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2015 appears to be lower with approximately 5,635 fish, which indicates a highly fluctuating and unstable ESU.

From 1993 to 2007 the 5-year moving average of the tributary population Cohort Replacement Rate remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011 (NMFS 2011c). The productivity of the Feather River and Yuba River populations and contribution to the CVSR Chinook salmon ESU is currently unknown, however the FRFH currently produces 2,000,000 juveniles each year. The cohort replacement rate (CRR) for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations.

While we currently lack data on naturally-produced juvenile CVSR Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The CDFG (1998) published estimates in which average fecundity of spring-run Chinook salmon is 4,161 eggs per female. By applying the average fecundity of 4,161 eggs per female to the estimated 5,734 females returning (half of the most recent five-year average of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the Sacramento River basin portion of the ESU could produce roughly 2.4 million natural outmigrants annually. In addition, hatchery managers could produce over two million listed hatchery juvenile CVSR Chinook salmon each year for the Sacramento River basin, and are expected to produce several hundreds of thousands of smolts for the experimental San Joaquin River basin (Table 3). For the San Joaquin River experimental population, it is possible that some of the experimental hatchery fish released in previous years will return to spawn this year. However, the outmigration and ocean survival rate of that group is unknown, so no estimate of their abundance is available. Therefore, an estimate of the abundance of the natural outmigrants those fish could produce is also not available.

Threats and Limiting Factors. Good et al. (2005) found that the CVSR Chinook salmon was likely to become endangered with the major concerns being low diversity, poor spatial structure and low abundance. Major factors and threats affecting, or potentially affecting, the CVSR Chinook status include: (1) dams, (2) diversions, (3) urbanization and rural development, (4) logging, (5) grazing, (6) agriculture, (7) mining, (8) estuarine alteration, (9) fisheries, (10) hatcheries, and (11) 'natural' factors (Moyle et al. 2008). Early reductions occurred with the hydraulic mining, logging, and overfishing of the California gold rush era (Yoshiyama et al. 1998). Currently, dams block access to 90 percent of historic spawning and summer holding areas including all of the San Joaquin River basin, the northern Sacramento River basin, and many central Sierra Nevada streams and basins (Yoshiyama et al. 1998). Besides blocking habitat, dams alter river flow regimes and temperatures. This combined with agriculture and associated water diversions further impacts CVSR Chinook salmon habitat (Moyle et al. 2008). For juvenile rearing habitat, the Sacramento River is mostly channelized, the Sacramento/San Joaquin River Delta diked, and the San Francisco estuary greatly modified and degraded, thus reducing developmental opportunities for juvenile salmon (Moyle et al. 2008). MacFarlane and Norton (2002) found that Chinook salmon passing through the San Francisco Estuary grow little and emerge into the ocean in a depleted condition with no accumulation of lipid energy reserves. Whether this is a result of a different evolutionary strategy or the result of an altered estuary, this is different than what is observed in other Chinook populations (MacFarlane and Norton 2002).

Status Summary. In summary, the status of the CVSR Chinook salmon ESU, until 2015, has probably improved since the 2010 status review. The largest improvements are due to extensive restoration, and increases in spatial structure with historically extirpated populations trending in the positive direction. Improvements, evident in the moderate and low risk of extinction of the three independent populations, however, are certainly not enough to warrant the delisting of the ESU. The recent declines of many of the dependent populations, high pre-spawn and egg mortality during the 2012 to 2015 drought, and uncertain juvenile survival during the drought, and ocean conditions, as well as the level of straying of FRFH spring-run Chinook salmon to other CVSR Chinook salmon populations are all causes for concern for the long-term viability of the CVSR Chinook salmon ESU.

2.2.2.2 Sacramento River Winter-run Chinook Salmon

Description and Geographic Range. On August 4, 1989, NMFS listed the SRWR Chinook salmon ESU —both natural and some artificially-propagated fish—as threatened (54 FR 32085). Their status was reclassified to "endangered" on January 4, 1994 (59 FR 440) and reaffirmed as endangered June 28, 2005 (70 FR 37160). Historically, the SRWR Chinook salmon includes salmon spawning in the upper Sacramento River tributaries and upper Battle Creek. The construction of Shasta and Keswick dams completely displaced this ESU from its historical spawning habitat and SRWR currently are represented by a single naturally-spawning population. . Two artificial propagation programs are considered to be part of the SRWR Chinook ESU (70 FR 37160) both carried out at the Livingston Stone National Fish Hatchery (NFH) but at two locations: the Livingston Stone NFH and at the University of California's Bodega Marine Laboratory. The target for the number of releases of SRWR Chinook salmon has been around 200,000 annually, and has averaged 193,900 in recent years, but USFWS have ramped up production of hatchery smolts in response to the drought, and have released 600,000 hatchery SRWR Chinook smolts in 2015 (USFWS 2012, CDFW 2015).

In 2015, the USFWS, NMFS, and CDFW collectively decided to initiate a Captive Broodstock Program using juvenile hatchery fish from the Conservation Hatchery Program. This decision was in response to threats to the ESU caused by the continuation of extreme drought conditions in California's Central Valley. The goals of a new Captive Broodstock Program will be to provide : 1) a genetic reserve of winter-run Chinook salmon to be available for use as hatchery broodstock for the Integrated- Recovery Supplementation Program in the event of a catastrophic decline in the abundance; 2) a future source of winter-run Chinook salmon to contribute to multi-agency efforts to reintroduce winter-run Chinook salmon upstream of Shasta Dam and into restored habitats of Battle Creek; and 3) a future source of winter-run Chinook salmon to fulfill the needs of research projects.

Spatial Structure and Diversity. The Central Valley Technical Recovery Team delineated four historical independent populations of SRWR Chinook salmon (Table 4). The spawning areas of three of these historical populations are above the impassable Keswick and Shasta dams, while Battle Creek (location of the fourth population) is presently unsuitable for winter-run Chinook salmon due to high summer water temperatures. The ESU as a whole could not be considered viable because there is only one naturally spawning population, and it is not within its historical range (Williams et al. 2011).

Table 4. Historical populations of SRWR Chinook salmon (Lindley et al. 2006).

Population	Status	Comment
Little Sacramento River	*Extinct*	Historic habitat blocked by Keswick and Shasta dams on Sacramento River, displaced population spawns downstream of dams
Pit River/Fall River/Hat Creek	*Extinct*	
McCloud River	*Extinct*	
Battle Creek	*Extinct*	Blocked by Coleman NFH and high water temperatures

Dam construction began to hamper runs in the early 1900s, and completion of the Shasta Dam in the early 1940s sealed off most of the spawning grounds (Botsford and Brittnacher 1996). The winter run then began to spawn in the waters downstream from Shasta Dam, which happened to be cooled by dam releases at the appropriate time of year (Fisher 1994). Completion of the Red Bluff Diversion Dam in 1967 hampered migration to and from the spawning area, but also provided a means of counting almost all spawning adults each year. In recent years, the gates of this dam have been open during most of the upstream spawning migration of the winter run to enhance upstream survival. Since migrants are no longer forced to use the counting ladder, this has greatly reduced the precision of this abundance estimate (Botsford and Brittnacher 1996).

Abundance and Productivity. The SRWR Chinook salmon is one of four historic Chinook runs for the Central Valley (spring, fall, late fall, and winter) (Yoshiyama et al. 1998). Fisher (1994) estimated SRWR Chinook spawning runs at 200,000 fish. Botsford and Brittnacher (1996) estimated SRWR Chinook salmon spawning runs ranging from 180,000 to 300,000 in the late 1800's before dam constructions began to obstruct runs. Like many other populations of Chinook salmon in the Central Valley, SRWR Chinook have declined in abundance since 2006 (Table 7). Since the 2010 viability assessment, routine escapement data have continued to be collected allowing viability statistics to be updated (Table 5). The Red Bluff Diversion Dam (RBDD) gates were operated in the up/out position during some or all of the winter-run immigration period since 2001 and removed in 2012 to provide unimpaired salmon passage year-round (NMFS 2009). These modifications changed the ability to count SRWR Chinook salmon adults at the RBDD fish ladders (NMFS 2009). Population estimates from 2001 to present are derived exclusively from mark-recapture estimates from the carcass survey

Table 5. Viability metrics for SR winter-run Chinook salmon ESU. Total population size (N) is estimated as the sum of estimated run sizes over the most recent three years. The mean population size ($\hat{S}$) is the average of the estimated run sizes for the most recent 3 years for which we have data (2012-2014). Population growth rate (or decline; 10-year trend) is estimated from the slope of log-transformed estimated run sizes. The catastrophic metric (Recent Decline) is the largest year-to-year decline in total population size (N) over the most recent 10 such ratios. (Williams et al. 2016).

Population	$\hat{S}$	N	10- year trend (95percent CI)	Recent Decline (percent)
Livingston Stone NFH	215.0	645	0.102 (-0.019, 0.222)	2.7
Sacramento River	3708.3	11125	-0.155 (-0.345, 0.034)	67.4

$\hat{S}$ – Estimated annual run size; N – Census population size

Since 2000, the proportion of hatchery-origin, SRWR Chinook spawning in the river has ranged up to 10 percent (Table 6), which is below the low-risk threshold for hatchery influence (Williams et al. 2011). The current average run size for the SRWR Chinook salmon ESU is 2,106 fish (2,023 natural-origin, 83 hatchery produced) (Table 6).

Table 6. Average abundance estimates for SRWR Chinook salmon natural- and hatchery-origin spawners 2001-2011 (Killam 2012, O'Farrell et al. 2012).

Year	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	Percent Hatchery Origin	Expected Number of Outmigrants[c]
2001	8,120	104	1.3	649,600
2002	7,360	104	1.4	588,800
2003	8,133	85	1.0	650,640
2004	7,784	85	1.1	622,720
2005	15,730	109	0.7	1,258,400
2006	17,197	99	0.6	1,375,760

Year	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	Percent Hatchery Origin	Expected Number of Outmigrants[c]
2007	2,487	55	2.2	198,960
2008	2,725	105	3.7	218,000
2009	4,416	121	2.7	353,280
2010	1,533	63	3.9	122,640
2011	738	89	10.8	59,040
ESU Average[d]	**2,023**	**83**	**3.9**	**161,840**

[a] Five-year geometric mean of post fishery natural-origin spawners (2007-2011).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2007-2011).
[c] Expected number of outmigrants=Total spawners*40 percent proportion of females*2,000 eggs per female*10 percent survival rate from egg to outmigrant
[d] Averages are calculated as the geometric mean of the annual totals (2007-2011).

Juvenile SRWR Chinook abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40 percent of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 809 females), the ESU is estimated to produce approximately 1.6 million eggs annually. The average survival rate in these studies was 10 percent, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10 percent, the ESU should produce roughly 161,840 natural outmigrants annually.

Limiting Factors. Major factors affecting, or potentially affecting, the SRWR Chinook status include: (1) dams, (2) diversions, (3) urbanization and rural development, (4) logging, (5) grazing, (6) agriculture, (7) mining, (8) estuarine alteration, (9) fisheries, (10) hatcheries, and (11) 'natural' factors (e.g. ocean conditions) (Moyle et al. 2008). Early reductions occurred with the hydraulic mining, logging, and overfishing of the California gold rush era (Yoshiyama et al. 1998). Currently, Shasta and Keswick dams block all historic spawning and rearing habitat for this ESU (Moyle et al. 2008). Besides blocking habitat, these dams alter river flow regimes and temperatures. Fortunately, the cold-water releases from Shasta Dam have allowed this ESU to continue to subsist (Yoshiyama et al. 1998). Unfortunately, during drought years water releases decrease and temperatures increasing decreasing reproduction downstream (Yoshiyama et al. 1998). Additionally, impaired water quality from pesticide and herbicide associated with agriculture reduces habitat quality (Williams et al. 2011). For juvenile rearing habitat, the Sacramento River is mostly channelized, the Sacramento/San Joaquin River Delta diked, and the San Francisco estuary greatly modified and degraded; thus reducing developmental opportunities for juvenile salmon (Moyle et al. 2008). MacFarlane and Norton (2002) found that Chinook salmon passing through the San Francisco Estuary grow little and emerge into the ocean in a depleted condition with no accumulation of lipid energy reserves. Whether this is a result of a different evolutionary strategy or the result of an altered estuary, this is different from what is observed in other Chinook populations (MacFarlane and Norton 2002).

Status Summary. The status of SRWR Chinook salmon has changed little since the last status review. While some conservation measures have been successful in improving habitat conditions for the SRWR Chinook salmon ESU since it was listed in 1989, fundamental problems with the quality of remaining habitat still remain (see Lindley et al. 2009, Cummins et al. 2008, and NMFS 2014). As such, the habitat supporting this ESU remains in a highly degraded state and it is unlikely that habitat quality has substantially changed since the last status review in 2010 (NMFS 2011). Overall, major habitat expansion and restoration for SR winter-run Chinook salmon has not occurred as of this review, and because of that, the loss of historical habitat and the degradation of remaining habitat continue to be major threats to the SR winter-run Chinook salmon ESU.

2.2.2.3 California Coastal Chinook Salmon

Description and Geographic Range. On September 16, 1999, NMFS listed naturally spawned CC Chinook salmon as a threatened species (64 FR 50394). The listing status has been reaffirmed in three subsequent status reviews (Good et al. 2005, Williams et al. 2011, Williams et al. 2016) This listing noted that artificially propagated populations of this ESU are not considered part of this listing. Historically there were seven artificial propagation programs for CC Chinook salmon, however all seven programs were terminated prior to 2011 (Williams et al. 2011). The 2005 Biological Review Team (BRT) concluded that the CC Chinook salmon ESU is likely to become endangered (Good et al. 2005). Widespread declines in abundance and the present distribution of small populations with sometimes sporadic occurrences contribute to the risks faced in this ESU. The BRT is concerned about the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity, and distribution of Chinook salmon in this ESU (Good et al. 2005). NMFS promulgated 4(d) protective regulations for CC Chinook salmon on January 9, 2002 (67 FR 1116), and the 4(d) protective regulations were amended on June 28, 2005 (70 FR 37160).

The CC Chinook salmon ESU includes all naturally spawned populations of Chinook salmon in rivers and streams from Redwood Creek (Humboldt County) south to the Russian River (Sonoma County), inclusive. The extant ESU consists of only a fall-run life history type (Good et al. 2005).

Spatial Structure and Diversity. Bjorkstedt et al. (2005) concluded that the CC Chinook salmon ESU was historically composed of approximately 32 Chinook salmon populations. However, various status reviews have noted that many of these populations (14 to 17) were independent, or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts, with the remaining populations being likely dependent on the existence of nearby populations in order to persist (Bjorkstedt et al. 2005, Good et al. 2005, Spence et al. 2008, Williams et al. 2011). Table 8 lists the historical CC Chinook functionally and potentially independent populations (Bjorkstedt et al. 2005). Spence et al. (2008) concluded that the CC Chinook salmon ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook, and an unknown number of dependent populations. However, based on the data available, eight of the 16 populations were classified as data deficient, one population (Mattole River) was classified as being at a Moderate/High risk of extirpation, and six populations (Ten Mile River, Noyo River, Big River, Navarro River, Garcia River, and Gualala

River) were classified as being at a High risk of extirpation. Overall, Spence et al. (2008) concluded that the CC Chinook salmon ESU is at an elevated risk of extirpation, which was consistent with previous status reviews (Myers et al. 1998, Good et al. 2005).

CC Chinook salmon populations remain widely distributed throughout much of the ESU. Notable exceptions include the area between the Navarro River and Russian River and the area between the Mattole and Ten Mile River populations (Lost Coast area). The lack of Chinook salmon populations both north and south of the Russian River (the Russian River is at the southern end of the species' range) makes it one of the most isolated populations in the ESU. Myers et al. (1998) reports no viable populations of Chinook salmon south of San Francisco, California.

Because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt et al. 2005). It is therefore likely that CC Chinook salmon genetic diversity has been adversely affected despite the relatively wide distribution of populations in the ESU. An apparent loss of the spring-run Chinook life history in the Eel River Basin and elsewhere in the ESU also indicates risks to the diversity of the ESU.

Table 7. Historical CC Chinook Functionally and Potentially Independent Populations (Bjorkstedt et al. 2005).

Population Groups	Run	Populations
Northern Mountain Interior	Fall	Lower Eel River, Van Duzen River, Upper Eel River, North Fork Eel River, Middle Fork Eel River
	Spring	Redwood Creek, Mad River, Van Duzen River, North Fork Eel River, Middle Fork Eel River, Upper Fork Eel River
North Coastal	Fall	Redwood Creek, Little River, Mad River, Humboldt Bay, Lower Eel River, South Fork Eel River, Bear River, Mattole River
North-Central Coastal	Fall	Ten Mile River, Noyo River, Big River
Central Coastal	Fall	Navarro River, Garcia River, Gualala River, Russian River

Abundance and Productivity. Historic data on CC Chinook abundance are sparse and of varying quality (Bjorkstedt et al. 2005). No estimates of absolute abundance are available for any population in this ESU (Myers et al. 1998). In 1965, CDFG (1965) estimated escapement for this ESU at over 76,000. Most were in the Eel River (55,500), with smaller populations in

Redwood Creek (5,000), Mad River (5,000), Mattole River (5,000), Russian River (500) and several smaller streams in Humboldt County (Myers et al. 1998).

Williams et al. (2011, 2016) indicated that a lack of population-level estimates of abundance for CC Chinook salmon populations continued. The available data evaluated by Williams et al. (2011, 2016), a mixture of partial population estimates and spawner/redd indexes showed somewhat mixed patterns, with few of the trends being statistically significant, and significant trends were not consistent in direction (Williams et al. 2011, 2016). Williams et al. (2011, 2016) did not find evidence of a substantial change in the status of the CC Chinook ESU since the previous status review (Good et al. 2005). However, they noted the deleterious loss of representation from one diversity stratum, the loss of the spring-run life history type, and the diminished connectivity between populations in the northern and southern half of the ESU.

Although there is limited population-level estimates of abundance for CC Chinook salmon populations, Table 8 summarizes the information that is available for the major watersheds in the ESU. Based on this limited information, the current average run size for CC Chinook ESU is 7,034 adults (Table 8). While we currently lack data on naturally-produced juvenile CC Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Juvenile CC Chinook salmon population abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Average fecundity for female CC Chinook is not available. However, Healey and Heard (1984) indicates that average fecundity for Chinook salmon in the nearby Klamath River is 3,634 eggs for female. By applying an average fecundity of 3,634 eggs per female to the estimated 3,517 females returning (half of the average total number of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the ESU could produce roughly 1,278,078 natural outmigrants annually.

Table 8. Abundance Geometric Means for Adult CC Chinook Salmon Natural-origin Spawners (Metheny and Duffy 2014, PFMC 2013, Ricker et al. 2014, http://www.pottervalleywater.org/van_arsdale_fish_counts.html, Mattole Salmon Group 2011, http://www.scwa.ca.gov/chinook/).

Population	Years	Spawners	Expected Number of Outmigrants[a,b]
Redwood Creek	2009-2013	1,745	317,067
Mad River	2010-2015	71	12,900
Freshwater Creek	2010-2015	6	1,090
Eel River mainstem	2010-2015	1,198	217,677
Eel River (Tomki Creek)	2010-2015	70	12,719
Eel River (Sproul Creek)	2010-2015	103	18,715
Mattole River	2007-2009, 2012, 2013	648	117,742
Russian River	2009 - 2014	3,137	569,993

Population	Years	Spawners	Expected Number of Outmigrants[ab]
Ten Mile River	2009 - 2014	6	1,090
Noyo River	2009 - 2014	14	2,544
Big River	2009 - 2014	13	2,362
Albion River	2009 - 2014	15	2,726
Navarro River	2009 - 2014	3	545
Garcia River	2009 - 2014	5	909
Total		**7,034**	**1,278,078**

[a]Expected number of outmigrants=Total spawners*50 percent proportion of females*3,634 eggs per female*10 percent survival rate from egg to outmigrant.
[b]Based upon number of natural-origin spawners.

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Threats and Limiting Factors. Many stressors and threats have contributed to the decline in CC Chinook salmon populations, including: (1) logging and road construction, (2) estuarine alteration, (3) dams and barriers, (4) climate change, (5) urbanization and agriculture, (6) gravel mining, (7) alien species, and (8) hatcheries (Moyle et al. 2008). Logging and associated stream crossing roads have altered the substrate composition, increased the sediment load, and reduced riparian cover, resulting in abiotic conditions that did not promote juvenile salmonid growth or survival. Estuaries at the mouths of Redwood Creek, Humboldt Bay tributaries, and the Eel River have lost complexity and habitat as a result of draining and diking (Moyle et al. 2008).

Dams on the Mad, Eel, and Russian, including an interbasin transfer of Eel River flows into the Russian river, have diminished downstream habitats through altered flow regimes and gravel recruitment (Moyle et al. 2008). Urbanization and agriculture occurring low in many of these watersheds result in degraded water quality from urban pollution and agricultural runoff. Gravel mining in the Mad, Eel, Van Duzen, Russian River, and Redwood Creek has created barriers to migration, stranding of adults, and promoted spawning in locations that do not maintain flows for incubation (Moyle et al. 2008). Alien fish predators, most notably Sacramento Pikeminnow, which are native to the Russian River but were introduced to the Eel River, are likely suppressing salmon populations in the Eel and other rivers (Moyle et al. 2008). Finally, several small hatchery operations historically produced and released CC Chinook salmon without monitoring the effects of hatchery releases on wild spawners (Moyle et al. 2008).

Status Summary. The lack of long-term population-level estimates of abundance for Chinook salmon populations in the CC Chinook salmon ESU continues to limit assessment of status, though the situation is improving with implementation of the Coastal Monitoring Plan (CMP) in the Mendocino Coast Region and portions of Humboldt County (Spence 2016). There has been a mix in population trends, with some population escapement numbers increasing and others decreasing. Overall, there is a lack of compelling evidence to suggest that the status of these populations has improved or deteriorated appreciably since the previous status review (Williams et al. 2011, Spence 2016, William et al. 2016).

At the ESU level, the loss of the spring-run life history type represents a significant loss of diversity within the ESU, as reported in previous status reviews (Good et al. 2005; Williams et al. 2011). Concern remains about the extremely low numbers of Chinook salmon in most populations of the North-Central Coast and Central Coast strata, which reduces connectivity across the ESU. However, the fact that Chinook salmon have regularly been reported in the Ten Mile, Noyo, Big, Navarro, and Garcia rivers represents an improvement in our understanding of the status of these populations in watersheds where they were thought to have been extirpated (Spence 2016). These observations suggest that spatial gaps between extant populations are not as extensive as previously believed. In summary, the new information available since the last status review (Williams et al. 2011) does not appear to suggest there has been a change in extinction risk for this ESU (Williams et al. 2016).

2.2.2.4 Southern Oregon/Northern California Coast Coho Salmon

Description and Geographic Range. The Southern Oregon/Northern California Coasts (SONCC) coho salmon was first listed as threatened on May 6, 1997. When we re-examined the status of this species in 2005, 2011 and 2016, we determined that it still warranted listing as threatened (70 FR 37160, 76 FR 50448, 81 FR 33468). The listing includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. The ESU includes coho salmon from three hatchery programs: the Cole Rivers Hatchery Program, Trinity River Hatchery Program; and the Iron Gate Hatchery Program (79 FR 20802).

In contrast to the life history patterns of other anadromous salmonids, coho salmon generally exhibit a relatively short and fixed 3-year life cycle. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas for up to 15 months. Parr typically undergo a smolt transformation in their second spring, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. Adults typically begin their spawning migration in the late summer and fall, spawn by mid-winter, then die. Coho salmon typically spend two growing seasons in the ocean before returning to their natal stream to spawn as 3-year-olds. Some precocious males, called "jacks," return to spawn after only six months at sea (i.e., as 2-year-olds).

Spatial Structure and Diversity. Williams et al. (2006) characterized the SONCC ESU as three large populations that penetrate far inland (interior basins) and multiple smaller coastal populations (coastal basins). Populations that had minimal demographic influence from adjacent populations and were viable-in-isolation were classified as functionally independent populations. Populations that appeared to have been viable-in-isolation but were demographically influenced by adjacent populations were classified as potentially independent populations. Small populations that do not have a high likelihood of sustaining themselves over a 100-year time period in isolation and receive sufficient immigration to alter their dynamics and extirpation risk were classified as dependent. The last category, ephemeral populations, do not have a high likelihood of sustaining themselves over a 100-year time period in isolation, and do not receive sufficient immigration to affect this likelihood. The habitat supporting an ephemeral population is expected to be only rarely occupied. Table 10 lists the historical SONCC coho salmon functionally independent, potentially independent, dependent and ephemeral populations (Williams et al. 2006).

Table 9. Arrangement of Historical Populations of the SONCC Coho Salmon ESU. Population Types are Functionally Independent (F), Potentially Independent (P), Dependent (D) and Ephemeral (E) (Williams et al. 2006).

Diversity Stratum	Pop. Type	Population	Diversity Stratum	Pop. Type	Population
Northern Coastal	F	Elk River	Southern Coastal	F	Humboldt Bay tribs
	P	Lower Rogue River		F	Low. Eel/Van Duzen
	F	Chetco River		P	Bear River
	P	Winchuck River		F	Mattole River
	E	Hubbard Creek		D	Guthrie Creek
	E	Euchre Creek	Interior – Rogue	F	Illinois River
	D	Brush Creek		F	Mid. Rogue/Applegate
	D	Mussel Creek		F	Upper Rogue River
	D	Hunter Creek	Interior – Klamath	P	Middle Klamath River
	D	Pistol River		F	Upper Klamath River
Central Coastal	F	Smith River		P	Salmon River
	F	Lower Klamath River		F	Scott River
	F	Redwood Creek		F	Shasta River
	P	Maple Creek/Big	Interior – Trinity	F	South Fork Trinity
	P	Little River		P	Lower Trinity River
	F	Mad River		F	Upper Trinity River
	D	Elk Creek	Interior – Eel River	F	South Fork Eel River
	D	Wilson Creek		P	Mainstem Eel River
	D	Strawberry Creek		P	Mid. Fork Eel River
	D	Norton/Widow White		F	Mid. Mainstem Eel River

The interior sub-basin strata were divided into substrata representing the three major sub-basins of the Rogue, Klamath, and Eel basins. However, sufficient geographical and environmental variability occurs in the Klamath basin, therefore the Klamath basin was split into sub-strata of the Klamath River (upstream of the confluence with the Trinity River) and the Trinity River. The lower portions of these three large basins were included in the coastal basins sub-strata because they are more similar to other coastal basins in terms of the environmental and ecological characteristics examined than interior portions of the large basins.

Across the coastal basins of the SONCC coho Salmon ESU, there existed sufficient geographical and environmental variability resulting in the Technical Review Team dividing the coastal basins into three sub-strata. The northern sub-stratum includes basins from the Elk River to the Winchuck River, including the lower portion of the Rogue River. The central substratum includes coastal basins from the Smith River to the Mad River, including the lower portion of the Klamath River. The southern stratum includes the Humboldt Bay tributaries south to the Mattole River, including the lower Eel River and Van Duzen River.

The primary factors affecting the genetic and life history diversity of SONCC coho salmon appear to be low population abundance and the influence of hatcheries and out-of-basin introductions. Although the operation of a hatchery tends to increase the abundance of returning adults, the reproductive success of hatchery-born salmonids spawning in the wild can be less than that of naturally produced fish (Araki et al. 2007). As a result, the higher the proportion of hatchery-born spawners, the lower the overall productivity of the population, as demonstrated by Chilcote (2003). Williams et al. (2008) considered a population to be at least at a moderate risk of extirpation if the contribution of hatchery coho salmon spawning in the wild exceeds five percent. Populations have a lower risk of extirpation if no or negligible ecological or genetic effects resulting from past or current hatchery operations can be demonstrated. Because the main stocks in the SONCC coho salmon ESU (i.e., Rogue River, Klamath River, and Trinity River) remain heavily influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp et al. 1995, Good et al. 2005), some of these populations are at high risk of extirpation relative to the genetic diversity parameter.

In addition, some populations are extirpated or nearly extirpated (i.e., Middle Fork Eel, Bear River, Upper Mainstem Eel) and some brood years have low abundance or may even be absent in some areas (e.g., Shasta River, Scott River, Mattole River, Mainstem Eel River), which further restricts the diversity present in the ESU. The ESU's current genetic variability and variation in life history likely contribute significantly to long-term risk of extinction. Given the recent trends in abundance across the ESU, the genetic and life history diversity of populations is likely very low and is inadequate to contribute to a viable ESU.

NMFS recognizes that artificial propagation can be used to help recover ESA-listed species, but it does not consider hatcheries to be a substitute for conserving the species in its natural habitat. Potential benefits of artificial propagation for natural populations include reducing the short-term risk of extirpation, helping to maintain a population until the factors limiting recovery can be addressed, reseeding vacant habitat, and helping speed recovery. Artificial propagation could have negative effects on population diversity by altering life history characteristics such as smolt age and migration, and spawn timing.

Abundance and Productivity. Although long-term data on coho abundance in the SONCC Coho Salmon ESU are scarce, all available evidence from shorter-term research and monitoring efforts indicate that conditions have worsened for populations in this ESU since the early 2000's (Williams et al. 2011, 2016). For all available time series (except the parietal counts from West Branch and East Fork of Mill Creek), recent population trends have been downward. The longest existing time series at the "population unit" scale is from the Shasta River, which indicates a significant negative trend.

In the 2011 status evaluation, none of the time series examined (other than West Branch and East Fork Mill Creek) had a positive short-term trend and examination of these time series indicates that the strong 2001 broodyear was followed by a decline across the entire ESU (Williams et al. 2011). The exception being the Rogue Basin estimate from Huntley Park that exhibited a strong return year in 2004, stronger than 2001, followed by a decline to 414 fish in 2008, the lowest estimate since 1993 and the second lowest going back to 1980 in the time series.

Recent returns of naturally-produced adults to the Rogue, Trinity, Shasta, and Scott rivers have been highly variable. Wild coho salmon estimates derived from the beach seine surveys at Huntley Park on the Rogue River ranged from 414 to 24,481 naturally produced adults between 2003 and 2012 (Table 10). Similar fluctuation are noted in the Trinity, Shasta, and Scott river populations. Overall, the average annual abundance, for populations where we have abundance data, of naturally produced fish is only 5,586. However, abundance data is lacking for the Eel, Smith, and Chetco rivers, the other major populations in the ESU, as well as the numerous smaller coastal populations. Actual abundance is therefore certain to be higher than this estimate.

Table 10. Estimates of the Natural and Hatchery Adult Coho Returning to the Rogue, Trinity, and Klamath rivers (ODFW 2016a, Kier et al 2015, CDFW 2012).

YEAR	Rogue River		Trinity River		Klamath River		
					Shasta [a]	Scott [a]	Salmon
	Hatchery	Natural	Hatchery	Natural	Natural	Total	Natural
2008	158	414	3,851	944	30	62	
2009	518	2,566	2,439	542	9	81	
2010	753	3,073	2,863	658	44	927	
2011	1,156	3,917	9,009	1,178	62	355	
2012	1,423	5,440	8,662	1,761		201	
2013	1,999	11,210	11,177	4,097			
2014	829	2,409	8,712	917			
Average [b]	**1,417**	**6,353**	**9,517**	**2,258**	**38**	**357**	**50 [c]**

[a] Hatchery proportion unknown, but assumed to be low.
[b] 3-year average of most recent years of data.
[c] Annual returns of adults are likely less than 50 per year (NMFS 2012).

While we currently lack data on naturally-produced juvenile coho salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Quinn (2005) published estimates for salmonids in which average fecundity for coho salmon is 2,878 eggs per female. By applying the average fecundity of 2,878 eggs per female to the estimated 9,995 females returning (half of the average total number of spawners), approximately 28 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can state that the ESU could produce roughly 2 million juvenile natural SONCC coho salmon each year. In addition, hatchery managers could produce approximately 775,000 listed hatchery juvenile coho each year (Table 11).

Table 11. SONCC Coho Salmon Listed Hatchery Stock Annual Juvenile Production Goals (ODFW 2010f; California HSRG 2012).

Artificial propagation program	Location (State)	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clipped
Cole Rivers Hatchery (ODFW stock #52)	Rogue River (Oregon)	0	200,000
Trinity River Hatchery	Trinity River (California)	500,000	N/A
Iron Gate Hatchery	Klamath River (California)	75,000	N/A

The productivity of a population (i.e., production over the entire life cycle) can reflect conditions (e.g., environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany et al. 2000). In general, declining productivity equates to declining population abundance. As discussed above in the population abundance section, available data indicates that many populations have declined, which reflects a declining productivity. For instance, the Shasta River population has declined in abundance by almost 50 percent from one generation to the next (Williams et al. 2011 and NMFS 2012). Two partial counts from Prairie Creek, a tributary of Redwood Creek, and Freshwater Creek, a tributary of Humboldt Bay indicate a negative trend (NMFS 2012). Data from the Rogue River basin also show recent negative trends. In general, SONCC coho salmon have declined substantially from historic levels. Because productivity appears to be negative for most, if not all SONCC coho salmon populations, this ESU is not currently viable in regard to population productivity.

Threats and Limiting Factors. There are several factors and threats that have contributed to the decline of SONCC coho salmon. Stream-flow diversions are common throughout the species' ranges. Unscreened diversions for agricultural, domestic and industrial uses are a significant factor for salmonid declines in many basins. Reduced stream-flows due to diversions reduce the amount of habitat available to salmonids and can degrade water quality. Reductions in water quantity can and will reduce the carrying capacity of the affected stream reach. Where warm return flows enter the stream, fish may seek reaches with cooler water if passage conditions are adequate, thus increasing competitive pressures in other areas.

Habitat blockages that have occurred from road construction and hydropower, flood control, and water supply dams, particularly in the Klamath basin, have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. Since 1918, the completion of Copco 1 Dam has blocked coho salmon access into upstream reaches of the Klamath River and its tributaries. In addition, the construction of Iron Gate Dam further blocked coho salmon access to upstream habitat. On the Eel River, the construction of the Potter Valley Project dams beginning in 1908 blocked access to a majority of the historic salmonid habitat in the mainstem Eel River watershed. As a result of migration barriers, salmon and steelhead populations have been generally confined to lower elevation mainstems that were historically only used for migration and rearing. Higher temperatures at these lower elevations during late- summer and fall are also a major stressor to adult and juvenile salmonids. Population abundances have declined in many streams due to decreased quantity, quality, and spatial distribution of spawning and rearing habitat (Lindley et al. 2007).

Harvest impacts include mark-selective (hatchery) coho fisheries and Chinook-directed fisheries in Oregon and non-retention impacts in California. California has prohibited coho salmon-directed fisheries and coho salmon retention in the ocean since 1996. The Rogue/Klamath coho salmon ocean exploitation rate averaged six percent from 2000–2007 before declining to one percent and three percent in 2008 and 2009, respectively, due to closure of nearly all salmon fisheries south of Cape Falcon, Oregon. For 2010, the forecasted rate was 10 percent (PFMC 2010) primarily due to the resumption of recreational fishing off California and Oregon.

Tribal harvest is not considered to be a major threat. Estimates of the harvest rate for the Yurok fishery averaged four percent from 1992–2005 and five percent from 2006–2009 (Williams 2010). We do not have harvest rate estimates for the other two tribal fisheries.

Recreational harvest of SONCC coho salmon has not been allowed since 1994, with the exception being a mark-selective recreational coho salmon fishery that has taken place in recent years in the Rogue River and Oregon coastal waters. The Pacific Fishery Management Council (PFMC) (PFMC 2009) estimated that 3.3 percent of Rogue/Klamath coho salmon accidentally caught in this mark-selective fishery would die on release. However, no recent assessments of coho salmon bycatch have occurred in Oregon or California. Overall, the threat to the SONCC coho salmon ESU from recreational fishing is unknown, but is likely to be a factor for decline (NMFS 2011a).

Recent studies have raised concerns about the potential impacts of hatchery fish predation on natural coho salmon populations. Hatchery fish can exert predation pressure on juvenile coho salmon in certain watersheds. Released at larger sizes than naturally produced juveniles and in great quantity, hatchery-reared salmonids will often prey on naturally-produced juvenile coho (Kostow 2009). There is evidence that predation by hatchery fish may result in the loss of tens of thousands of naturally produced coho salmon fry annually in some areas of the Trinity River (Naman 2008).

Status Summary. The Good et al. (2005) review concluded that the SONCC coho salmon ESU was likely to become endangered. Since that review, the apparent negative trends across the ESU are of great concern as is the lack of information necessary to determine if there has been a substantial improvement in freshwater habitat and survival. Williams et al. (2011) review indicates that the biological status of SONCC coho salmon ESU has worsened since the 2005 status review and factors such as ocean survival conditions, drought effects, and small population size are continuing sources of concern. Williams et al. (2016) review indicates that the collective risk to the SONCC coho salmon's persistence has not changed significantly since the 2011 status review but the overall level of concern has increased based on predicted effects from increased water withdrawal in many areas and on drought conditions, and there has been no apparent trend toward recovery since listing.

2.2.2.5 Central California Coast Coho Salmon

Description and Geographic Range. This ESA includes all naturally spawned coho salmon originating from rivers south of Punta Gorda, California to and including Aptos Creek, as well as coho salmon originating from tributaries to San Francisco Bay. The Central California Coast (CCC) coho salmon ESU was originally listed as threatened in 1996 (61 FR 56138). In 2005 following a reassessment of its status and after applying NMFS' hatchery listing policy, we reclassified the ESU as endangered and listed several conservation hatchery programs (Don Clausen Fish Hatchery Captive Broodstock Program; the Scott Creek/King Fisher Flats Conservation Program; and the Scott Creek Captive Broodstock program) that were associated with the ESU (70 FR 37160).

Spatial Structure and Diversity Historically, the Central California Coast (CCC) coho salmon ESU comprised approximately 76 coho salmon populations. Most of these were dependent populations that needed immigration from other nearby populations to ensure their long term survival. Historically, there were 11 functionally independent populations and one potentially independent population of CCC coho salmon (Table 12) (Spence et al. 2008, Spence et al. 2012). Adams et al. (1999) found that in the mid 1990's coho salmon were present in only 51 percent (98 of 191) of the streams where they were historically present, although coho salmon were documented in 23 additional streams within the CCC coho salmon ESU for which there were no historical records. Recent genetic research by the SWFSC and the Bodega Marine Laboratory has documented a reduction in genetic diversity within subpopulations of the CCC coho salmon ESU (Bjorkstedt et al. 2005).

Table 12. Historical independent populations of CCC coho salmon (Bjorkstedt et al. 2005, Williams et al. 2011).

Stratum	Population	Extinction Risk
Lost Coast – Navarro Point	Ten Mile River	Unknown
	Noyo River	Moderate/High
	Big River	Unknown
	Albion River	Unknown
Navarro Point – Gualala Point	Navarro River	Unknown
	Garcia River	High
	Gualala River	High
Coastal	Russian River	High
	Walker Creek	High
	Lagunitas Creek	Unknown
Santa Cruz Mountains	Pescadero Creek	High
	San Lorenzo River	High

The North-Central California Coast Technical Recovery Team (NCCC TRT) based their extinction risk analysis upon ancillary data due to a lack of time series-abundance data for the ESU (Spence et al. 2008, Williams et al. 2011). The NCCC TRT concluded that CCC coho salmon were at high risk of extinction in the Garcia River, Gualala River, Russian River, Walker

Creek, Pescadero Creek, and San Lorenzo River watersheds. The Noyo River population was deemed to be at moderate/high risk. The remaining independent populations were considered data deficient. The lack of demonstrably viable populations in any of the diversity strata, the lack of redundancy in viable populations, and substantial spatial gaps in the distribution of coho salmon led the NCCC TRT to conclude that the CCC Coho Salmon ESU was in danger of extinction (NMFS 2012b).

Abundance and Productivity. Brown et al. (1994) estimated that annual spawning numbers of coho salmon in California ranged between 200,000 and 500,000 fish in the 1940's, which declined to about 100,000 fish by the 1960's, followed by a further decline to about 31,000 fish by 1991. More recent abundance estimates vary from approximately 600 to 5,500 adults (Good et al. 2005). Recent status reviews (Good et al. 2005; Williams et al. 2011; NMFS 2016c) indicate that the CCC coho salmon are likely continuing to decline in number and many independent populations that supported the species overall numbers and geographic distributions have been extirpated. The current average run size for the CCC coho salmon ESU is 1,621 fish (1,294 natural-origin; 327 hatchery produced).

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 647 females returning (50 percent of the run) to this ESU, one may expect approximately 1.3 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can estimate that roughly 90,000 juvenile coho salmon are produced annually by the CCC coho ESU.

Limiting Factors. Threats and Limiting Factors. Most of the populations in the CCC coho salmon ESU are currently doing poorly; low abundance, range constriction, fragmentation, and loss of genetic diversity is documented. The near-term (10 - 20 years) viability of many of the extant independent CCC coho salmon populations is of serious concern. These populations may not have enough fish to survive additional natural and human caused environmental change. NMFS has determined that currently depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat: logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Impacts of concern include altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas (Weitkamp et al. 1995; Busby et al. 1996; 64 FR 24049; 70 FR 37160; 70 FR 52488). Diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle in many of the streams within the ESU.

Status Summary. Information on population status and trends for CCC Coho Salmon has improved considerably since the 2011 status review due to recent implementation of the Coastal Monitoring Program (CMP) across significant portions of the ESU. Most independent CCC coho salmon populations remain at critically low levels, with those in the southern Santa Cruz Mountains strata likely extirpated (NMFS 2016e). Data suggests some populations show a slight positive trend in annual escapement, but the improvement is not statistically significant. Overall, all CCC coho salmon populations remain, at best, a slight fraction of their recovery target levels, and, aside from the Santa Cruz Mountains strata, the continued extirpation of dependent populations continues to threaten the ESU's future survival and recovery (NMFS 2016e, Williams et al 2016).

2.2.2.6 California Central Valley Steelhead

Description and Geographic Range. On March 19, 1998, NMFS listed CCV steelhead—both natural and some artificially-propagated fish—as a threatened species (63 FR 13347). NMFS concluded that the CCV steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. The CCV steelhead DPS includes steelhead populations spawning in the Sacramento and San Joaquin rivers and their tributaries. Two artificial propagation programs were listed as part of the DPS—Coleman National Fish Hatchery and Feather River Hatchery winter-run steelhead hatchery stocks.

On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS and promulgated 4(d) protective regulations for CCV steelhead (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCV steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. In 2011 and 2016, NMFS completed 5-year status reviews of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (Williams et al. 2011, Williams et al. 2016).

Spatial Structure and Diversity. About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama et al. 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Latta 1977).

Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries (NMFS 2016f). Zimmerman et al. (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage exist in all three major San Joaquin River tributaries, although at low levels, and these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River watershed. The Mossdale trawls conducted by CDFW and USFWS each year catch steelhead smolts annually, although usually in very small numbers.

Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adult intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River. This is confounded by the fact that most of the dedicated monitoring programs in the Central Valley occur on rivers that are annually stocked. Clear Creek and Mill Creek are the exceptions (NMFS 2016f).

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of CCV populations if the passage programs are implemented for steelhead. In addition, the San Joaquin River Restoration Program calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the San Joaquin River Restoration Program is successful, habitat improved for spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2011c).

CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen et al. 2003). (Garza and Pearse 2008), analyzed the genetic relationships among Central Valley steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extirpation (Lindley et al. 2007). There are four hatcheries (Coleman NFH, FRFH, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year (Table 13). These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS.

Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002, McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CCV streams, presently located above impassible dams (Lindley et al. 2006).

Abundance and Productivity. Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock et al. (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the Red Bluff Diversion Dam (RBDD) declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being planned (Eilers et al. 2010).

Table 13. Expected Annual CCV Steelhead Hatchery Releases (CHSRG 2012).

Artificial propagation program	Clipped Adipose Fin
Nimbus Hatchery (American River)	439,490
Feather River Hatchery (Feather River)	**273,398**
Coleman NFH (Battle Creek)	**715,712**
Mokelumne River Hatchery (Mokelumne River)	172,053
Total Annual Release Number	**1,600,653**

Historic CCV steelhead abundance is unknown. In the mid-1960's, the California Department of Fish and Game (CDFG) (now CDFW) estimated CCV steelhead abundance at 26,750 fish (CDFG 1965). The CDFG estimate, however, is just a midpoint number in the CCV steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest, dam construction, and urbanization.

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams et al. 2011).

In contrast to the data from Chipps Island and the Central Valley Project and State Water Project fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011c). Since 2003, fish returning to the Coleman NFH have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely; ranging from 624 to 2,968 fish per year.

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data (Table 15). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 2,771 females), 9.7 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 630,403 naturally produced outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million listed hatchery juvenile CCV steelhead each year (Table 14).

Table 14. Abundance geometric means for adult CCV steelhead natural- and hatchery-origin spawners (CHSRG 2012, Hannon and Deason 2005, Teubert et al. 2011, additional unpublished data provided by the NMFS SWFSC)

Population	Years	Natural-origin Spawners	Hatchery-origin Spawners	Expected Number of Outmigrants[ab]
American River	2011-2015	208	1,068	145,145
Antelope Creek	2007	140	0	15,925
Battle Creek	2010-2014	410	1,563	224,429
Bear Creek	2008-2009	119	0	13,536
Cottonwood Creek[f]	2008-2009	27	0	3,071
Clear Creek	2011-2015	463	0	52,666
Cow Creek	2008-2009	2	0	228
Feather River	2011-2015	41	1,092	128,879
Mill Creek	2010-2015	166	0	18,883
Mokelumne River	2006-2010	110	133	27,641
Total		**1,686**	**3,856**	**630,403**

[a] Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant

[b] Based upon number of natural-origin spawners

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Threats and Limiting Factors. Many threats and factors have contributed to the decline of CCV steelhead, including, (1) major dams, (2) water diversions, (3) barriers, (4) levees and bank protection, (5) dredging and sediment disposal, (6) mining, (7) contaminants, (8) alien species, (9) fisheries, and (10) hatcheries (Moyle et al. 2008). Dams have had a large impact on CCV steelhead with 80 percent of steelhead habitat blocked by dams (Lindley et al. 2006). Even dams that provide enough water downstream of dams may not provide cool enough temperatures for steelhead during summer and fall months (Moyle et al. 2008). Hatcheries produce a magnitude more juveniles than what is now naturally produced. These hatchery fish have a negative impact by displacing wild steelhead juveniles through competition and predation, hatchery adults competing with wild adults for limited spawning habitat, and hybridization with fish from outside the basin (Moyle et al. 2008). Though harvest of natural-origin CCV steelhead is prohibited in the Central Valley, there is a fishery upon the hatchery-produced steelhead. Unintentional catch and releases may be having a deleterious impact upon the natural populations (Moyle et al. 2008).

Status Summary. Overall, the status of CCV steelhead appears to have changed little since the 2011 status review when the Technical Recovery Team concluded that the DPS was in danger of extinction. Further, there is still a general lack of data on the status of wild populations. There are some encouraging signs, as several hatcheries in the Central Valley have experienced increased returns of steelhead over the last few years. There has also been a slight increase in the percentage of wild steelhead in salvage at the south Delta fish facilities, and the percentage of wild fish in those data remains much higher than at Chipps Island. The new video counts at Ward Dam show that Mill Creek likely supports one of the best wild steelhead populations in the Central Valley, though at much reduced levels from the 1950's and 60's. Restoration and dam removal efforts in Clear Creek continue to benefit CCV steelhead. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates that natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain (NMFS 2016f).

2.2.2.7 Northern California Steelhead

Description and Geographic Range. On June 7, 2000, NMFS listed NC steelhead—both natural and some artificially-propagated fish—as a threatened species (65 FR 36074). NMFS concluded that the NC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Two artificial propagation programs were listed as part of the DPS—Yager Creek and North Fork Gualala River/Gualala River steelhead Project winter-run steelhead hatchery stocks; but both programs were terminated in the mid-2000's (NMFS 2007). NMFS promulgated 4(d) protective regulations for NC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural NC steelhead.

The DPS includes all naturally spawned populations of steelhead in rivers and streams from Redwood Creek (Humboldt County) south to the Gualala River (Mendocino County). Extant summer-run populations are found in Redwood Creek, Mad River, Eel River (Middle Fork), and Mattole River. The Central California Coast steelhead DPS begins at the Russian River and extends south to Aptos Creek. This leaves several *O. mykiss* populations in small watersheds between the Gualala and Russian rivers that are not currently assigned to either DPS. The NC steelhead DPS is comprised of both winter- and summer-run steelhead populations.

Spatial Structure and Diversity. Bjorkstedt et al. (2005) concluded that the NC steelhead DPS historically comprised 42 independent populations of winter-run steelhead (19 functionally independent and 23 potentially independent), and as many as 10 independent populations (all functionally independent) of summer-run steelhead. In addition, this DPS likely contained a minimum of 65 (and likely more) dependent populations of winter-run steelhead in smaller coastal watersheds, as well as small tributaries to the Eel River. Table 15 lists the historical NC steelhead independent populations, many of which are assumed to be extant (NMFS 2011a).

Table 15. Historical NC Steelhead Independent Populations (NMFS 2011a).

Population Groups	Run	Populations
Northern Coastal	Summer	Mad River (lower), Mattole River, Redwood Creek (lower), South Fork Eel River
	Winter	Humboldt Bay, Little River, Mattole River, Redwood Creek (lower), South Fork Eel River
Lower Interior	Winter	Woodman Creek, Chamise Creek, Tomki Creek, Outlet Creek
Northern Mountain Interior	Summer	Mad River (upper), Redwood Creek (upper), Upper Mid-mainstem Van Duzen Creek
	Winter	Larabee Creek, Middle Fork Eel River, North Fork Eel River, Redwood Creek (upper), Van Duzen Creek
North-Central Coastal	Winter	Big River, Caspar Creek, Noyo River, Ten Mile River, Usal Creek, Wages Creek
Central Coastal	Winter	Garcia River, Gualala River, Navarro River

Abundance and Productivity. Short- and long-term trends have been calculated for a few rivers in this DPS (Table 16). Abundance trends for Little River have been significantly negative with the annual abundance having not been above 20 during the past decade (Gallagher and Wright 2009, 2011, and 2012, Williams et al. 2011, Gallagher et al. 2013). In Redwood Creek, dive surveys have been conducted annually since 1981. The recent (16-year) trend has been positive (p = 0.029); however, the critically low abundance overshadows this recent trend (Williams et al. 2011). For the Upper Eel River, abundance data is gathered from the Van Arsdale Fish Station. The short-term trend for the upper Eel River is positive, but there were no significant trends for the other three rivers; Freshwater Creek, South Fork (SF) Noyo River, and Gualala River (Williams et al. 2011).

Table 16. Short- and Long-term Trends in NC Steelhead Abundance Based on Partial Population Estimates and Population Indices. Trends in Bold are Significantly Different from 0 at α=0.05 (Williams et al. 2011).

Stratum	Population (run)	Short-term Trend (95 percent CI)	Long-term Trend (95 percent CI)
Northern Coastal	**Humboldt Bay**		
	Freshwater Creek (winter)	-0.046 (-0.245, 0.153)	-
	Little River (winter)	**-0.231** (-0.418, -0.043)	
	Redwood Creek (summer)	**0.093** (0.011, 0.175)	-0.012 (-0.054, 0.029)
North Mountain-Interior	**Upper Eel River (winter)**	**0.062** (0.001, 0.123)	-
North-Central Coastal	**Noyo River**		
	SF Noyo River (winter)	0.004 (-0.115, 0.123)	-
Central Coast	**Gualala River**		
	Wheatfield Fork (winter)	0.000 (-0.361, 0.361)	-

From these studies, we estimate that the NC steelhead DPS has an annual abundance of 7,221 adults (Table 17).

Table 17. Geometric Mean Abundances of NC Steelhead Spawners by Population (Gallagher and Wright 2009, 2011, and 2012; Gallagher et al. 2013, Mattole Salmon Group 2011, Duffy 2011, Counts at Van Arsdale Fisheries Station), Harris and Thompson 2014, De Haven 2010, Metheny and Duffy 2014, Ricker et al. 2014, additional unpublished data provided by the NMFS SWFSC)

Stratum	Waterbody	Run	Years	Abundance	Expected Number of Outmigrants[a]
Northern Coastal	Elk Creek	Winter	2011, 2014	13	1,479
	Little River	Winter	2010-2014	10	1,138
	Mattole River	Winter	2012-2013	558	63,473

Stratum	Waterbody	Run	Years	Abundance	Expected Number of Outmigrants[a]
	Mattole River	Summer	2011-2015	92	10,465
	Redwood Creek	Winter	2010-2013	610	69,388
	Redwood Creek	Summer	2010-2014	7	796
	Prairie Creek	Winter	2007, 2008, 2010-2012	22	2,503
	Humboldt Bay	Winter	2011-2014	52	5,915
	Freshwater Creek	Winter	2010-2014	102	11,603
North Mountain-Interior	Eel River	Winter	2011-2015	389	44,249
	South Fork Eel River	Winter	2011-2014	574	65,293
	Van Duzen River	Summer	2011-2015	115	13,081
	Middle Fork Eel River	Summer	2010-2014	796	90,545
North-Central Coastal	Big River	Winter	2010-2014	465	52,894
	Caspar Creek	Winter	2010-2014	31	3,526
	Cottoneva Creek	Winter	2010, 2012, 2014	83	9,441
	Hare Creek	Winter	2010-2014	2	228
	Juan Creek	Winter	2012	39	4,436
	Noyo River	Winter	2010-2014	442	50,278
	SF Noyo River	Winter	2010-2014	79	8,986
	Pudding Creek	Winter	2010-2014	34	3,868
	Ten Mile River	Winter	2010-2014	382	43,453
	Usal Creek	Winter	2010-2013	54	6,143
	Wages Creek	Winter	2010, 2011, 2014	55	6,256
Central Coastal	Albion River	Winter	2010-2014	45	5,119
	Big Salmon Creek	Winter	2012-2013	84	9,555
	Brush Creek	Winter	2010-2014	6	683
	Garcia River	Winter	2010-2014	340	38,675
	Gualala River	Winter	2006-2010	1,066	121,258
	Navarro River	Winter	2010-2014	332	37,765
	North Fork Navarro River	Winter	2013-2014	342	38,903
Total				**7,221**	**821,389**

[a]Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile NC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile NC steelhead abundance estimates come from the escapement data (Table 17). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 2,143 females), 7.5 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 487,533 natural outmigrants annually (Table 21).

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Threats and Limiting Factors. Many factors and threats have contributed to the decline of NC steelhead, including: (1) dams and other barriers, (2) logging, (3) agriculture, (4) ranching, (5) fisheries, and (6) hatcheries. Two of the largest rivers, Eel and Mad rivers, in the DPS are dammed. Scott Dam blocks 90 percent of the habitat on the Upper Eel River and reduces the flows into the mainstem Eel River. Ruth Dam block 36 percent of potential steelhead habitat in Mad River. Elsewhere throughout the DPS, culverts and bridges create impassable barriers (Moyle et al. 2008). Logging throughout the region has increased stream sedimentation and temperatures, reduced canopy cover, destroyed instream habitat, and altered flow timing and volume (Moyle et al. 2008). Agriculture and ranching land practices can lead to destabilized and denuded stream banks, stream channelization, large woody debris removal, increased sedimentation, and water pollution (Spence et al. 1996, Moyle et al. 2008). Though fishery take on NC steelhead is prohibited, hatcheries produce steelhead for the fishery resulting in unintentional captures of and competition with natural-origin steelhead (Moyle et al. 2008). Other threats to NC steelhead include gravel extraction, streambed alteration, predation from introduced species (i.e. Sacramento pike minnow), poaching, and human disturbance (Moyle et al. 2008).

Status Summary. In summary, the availability of information on steelhead populations in the NC steelhead DPS has improved considerably in the past 5 years, thanks to implementation of the CMP across a significant portion of the DPS (Williams et al 2016). Nevertheless, significant gaps in information still remain, particularly in the Lower Interior and North Mountain Interior diversity strata, where there is very little information from which to assess status (Williams et al

2016). Overall, the available data for winter-run populations—predominately in the North Coastal, North-Central Coastal, and Central Coastal strata—indicate that all populations are well below viability targets, most being between 5 percent and 13 percent of these goals. There is a mix in trends regarding the longer and shorter time series. Thus, we have no strong evidence to indicate conditions for winter-run populations have worsened appreciably since the last status review (Williams *et al.* 2011, Williams et al 2016). Summer-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. In summary, the available information for winter-run and summer-run populations of NC steelhead do not suggest an appreciable increase or decrease in extinction risk since publication of the last status reviews (Williams et al. 2011, Williams et al. 2016).

2.2.2.8 Central California Coast Steelhead

Description and Geographic Range. On August 18, 1997, NMFS listed CCC steelhead—both natural and some artificially-propagated fish—as a threatened species (62 FR 43937). NMFS concluded that the CCC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Two artificial propagation programs were listed as part of the DPS—Scott Creek/Kingfisher Flat Hatchery (includes San Lorenzo River production) and Don Clausen Fish Hatchery (includes Coyote Valley Fish Facility production) winter-run steelhead hatchery stocks (Table 19). NMFS promulgated updated 4(d) protective regulations for CCC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCC steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

The CCC steelhead DPS includes winter-run steelhead populations from the Russian River (Sonoma County) south to Aptos Creek (Santa Cruz County) inclusive and eastward to Chipps Island (confluence of the Sacramento and San Joaquin rivers) and including all drainages of San Francisco, San Pablo, and Suisun bays.

Table 18. Approximate annual releases of hatchery CCC steelhead (J. Jahn, pers. comm., July 2, 2013).

Artificial propagation program	Adipose Fin-Clipped
Scott Creek/Kingfisher Flat Hatchery	3,220
San Lorenzo River	19,125
Don Clausen Fish Hatchery	380,338
Coyote Valley Fish Facility	246,208
Total Annual Release Number	**648,891**

Spatial Structure and Diversity. Bjorkstedt et al. (2005) concluded that the CCC steelhead DPS historically comprised 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead (Table 19). These populations were placed in five geographically based diversity strata

(Bjorkstedt et al. 2005; modified in Spence et al. 2008). Most of the coastal populations are assumed to be extant, however many of the Coastal San Francisco Bay and Interior San Francisco Bay populations are likely at high risk of extirpation due to the loss of historical spawning habitat and the heavily urbanized nature of these watersheds (Williams et al. 2011).

Table 19. Historical CCC Steelhead Populations (NMFS 2011a).

Diversity Strata	Populations
North Coastal	Austin Creek, Salmon Creek, Walker Creek, Lagunitas Creek, Green Valley Creek
Interior	Dry Creek, Maacama Creek, Mark West Creek, Upper Russian River
Santa Cruz Mountains	Aptos Creek, Pescadero Creek, Pilarcitos Creek, San Lorenzo Creek, San Gregorio Creek, Scott Creek, Soquel Creek, Waddell Creek
Coastal San Francisco Bay	Corte Madera Creek, Guadalupe River, Miller Creek, Novato Creek, San Francisquito Creek
Interior San Francisco Bay	Alameda Creek, Coyote Creek, Napa River, Petaluma River, San Leandro Creek, San Lorenzo Creek

Abundance and Productivity. Historic CCC steelhead abundance is unknown. In the mid-1960's, CDFG estimated CCC steelhead abundance at 94,000 fish (CDFG 1965). The CDFG estimate, however, is just a midpoint number in the CCC steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest and urbanization. Current CCC steelhead abundance is still not well known. Multiple short-term studies using different methodologies have occurred over the past decade.

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCC steelhead abundance estimates come from the escapement data (Table 20). All returnees to the hatcheries do not contribute to the natural population and are not used in this calculation. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 1,094 females), 3.8 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 248,771 natural outmigrants annually (Table 21) The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Table 20. Geometric Mean Abundances of CCC Steelhead Spawners Escapements by Population (Ettlinger et al. 2012, Jankovitz 2013, Natural abundance: Manning and Martini-Lamb (ed.) 2012, Atkinson 2010, Williams et al. 2011, Koehler and Blank 2012, additional unpublished data provided by the NMFS SWFSC).

			Abundance		
Stratum	**Waterbody**	**Years**	**Natural Origin**	**Hatchery Origin**	**Expected Number of Outmigrants[a,b]**
Northern Coastal	Austin Creek	2010-2012	63	-	7,166
	Lagunitas Creek	2009-2013	71	-	8,076
	Pine Gulch Creek	2010-2014	37		4,209
	Redwood Creek	2010-2014	18		2,048
	Walker Creek	2007-2010	29	-	3,299
Interior	Dry Creek	2011-2012	33	-	3,754
	Russian River	2008-2012	230	3,451	26,163
Santa Cruz Mountains	Aptos Creek	2007-2011	249	-	28,324
	Pescadero	2013-2015	361	-	41,064
	Gazos Creek	2013-2015	30	-	3,413
	Waddell Creek	2013-2014	73	-	8,304
	San Gregorio Creek	2014-2015	135	-	15,356
	San Lorenzo Creek	2013-2015	423	319	48,116
	San Pedro Creek	2013	38		4,323
	San Vicente Creek	2013-2015	35		3,981
	Scott Creek	2011-2015	120	96	13,650
	Soquel Creek	2007-2011	230	-	26,163
Central Coastal	Napa River	2009-2012	12	-	1,365
		Totals	**2,187**	**3,866**	**248,771**

[a]Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant

[b]Based upon natural-origin spawner numbers

CCC steelhead have experienced serious declines in abundance, and long-term population trends suggest a negative growth rate (Good et al. 2005). This indicates the DPS may not be viable in the long term. DPS populations that historically provided enough steelhead strays to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead have maintained a wide distribution throughout the DPS, roughly approximating the known historical distribution, CCC steelhead likely possess a resilience that is likely to slow their decline relative to other salmonid species in worse condition (*e.g.*, CCC coho salmon).

Current abundance trend data for the CCC steelhead remains extremely limited. Only the Scott Creek population provides enough of a time series to examine trends, and this population is influenced by hatchery origin fish. Natural-origin spawners have experienced a significant downward trend (slope = -0.220; p = 0.036) (Williams et al. 2011). Since we only have trend information on Scott Creek, trends for the majority of the DPS is unknown although most of the populations are presumed to be extant.

Threats and Limiting Factors. Several factors and threats have contributed to the decline of CCC steelhead. Moyle et al. (2008) summarized these into four broad categories: (1) dams and other barriers, (2) stream habitat degradation, (3) estuarine habitat degradation, and (4) hatcheries. For the DPS, an estimated 22 percent of the historical habitat is currently blocked by man-made barriers (Good et al. 2005). Besides blocking the upstream migration of steelhead, these barriers often change the characteristics of the stream by decreasing peak flows and changing water temperatures making them unfavorable for steelhead (Moyle et al. 2008). Stream habitat has been degraded by urbanization, agriculture (i.e. vineyards), road building, logging, mining, sewage discharge, and other actions (Moyle et al. 2008). The Russian River (one of the most productive steelhead streams in the DPS) is listed as an impaired water body by the Federal Clean Water Act due to high fecal pathogens, excessive sediment loads, and mercury pollution. Excessive sediment loads and encroachment degrade estuary habitat by urbanization and agriculture (Moyle et al. 2008). Other limiting factors include pollution, gravel mining, fisheries, floodplain connectivity, lack of large woody debris, predation, and competition (Moyle et al. 2008).

Status Summary. In summary, Williams et al. (2016) found little new evidence to suggest that the status of the DPS has changed appreciably in either direction since publication of the last status reviews (Good et al. 2005, Williams et al. 2011). The scarcity of information on CCC steelhead abundance makes it difficult to assess whether conditions have changed appreciably (Williams et al. 2011, Williams et al. 2016). In the North Coastal and Interior strata, steelhead still appear to occur in the majority of watersheds, and new information from 3 years of monitoring in the Santa Cruz Mountain stratum indicates that population sizes are perhaps higher than previously thought. However, monitoring and hatchery data in the Russian River watershed indicate a prevalence of hatchery fish over natural origin fish, and the Scott Creek population, which has the most robust population estimates in the DPS, has shown a downward abundance trend (Spence 2016). Further, the status of populations in the two San Francisco Bay diversity strata remains highly uncertain, and it is likely that many populations where historical habitat is now inaccessible due to dams and other passage barriers are likely at high risk of extinction (Spence 2016). In summary, while data availability for this DPS remains poor, there is little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since the last status review (Spence 2016).

2.2.2.9 South-Central California Coast Steelhead

Description and Geographic Range. On August 18, 1997, NMFS listed S-CCC steelhead—only natural-origin fish—as a threatened species (62 FR 43937). NMFS concluded that the S-CCC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. NMFS promulgated 4(d) protective regulations for S-

CCC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery S-CCC steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

S-CCC steelhead occupy rivers from the Pajaro River (Santa Cruz County, California), inclusive, south to, but not including, the Santa Maria River (San Luis Obispo County, California). Most rivers in this DPS drain from the San Lucia Mountain range, the southernmost section of the California Coast Ranges. Many stream and rive mouths in this area are seasonally closed by sand berms that form during the low water flows of summer. The climate is drier than for the more northern DPSs with vegetation ranging from coniferous forest to chaparral and coastal scrub.

Spatial Structure and Diversity. S-CCC steelhead populations are broken into four population groups: Interior Coast Range, Carmel River Basin, Big Sur Coast, and San Luis Obispo Terrace (Table 21). The Interior Coast Range population group is the furthest north population containing long alluvial valleys and montane summer climate refugia. The Carmel River Basin population group resides in a medium valley with a montane/marine summer climate refugia. The Big Sur Coast population group uses short, steep canyons with a marine refugia. And the southernmost population group, San Luis Obispo Terrace, uses coastal terrace with a marine/montane refugia. In 2002, NMFS surveyed 36 watersheds and found that between 86 and 94 percent of the historic watersheds were still occupied. Also, occupancy was determined for 18 watershed basins with no historical record of steelhead (NMFS 2012c).

Table 21. Historical S-CCC Steelhead Populations (NMFS 2012c).

Population Groups	Populations (north to south)
Interior Coast Range	Pajaro River, Gabilan Creek, Arroyo Seco, Upper Salinas Basin
Carmel River Basin	Carmel River
Big Sur Coast	San Jose Creek, Malpaso Creek, Garrapata Creek, Rocky Creek, Bixby Creek, Little Sur River, Big Sur River, Partington Creek, Big Creek, Vicente Creek, Limekiln Creek, Mill Creek, Prewitt Creek, Plaskett Creek, Willow Creek (Monterey Co.), Alder Creek, Villa Creek (Monterey Co.), Salmon Creek
San Luis Obispo Terrace	Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Pico Creek, San Simeon Creek, Santa Rosa Creek, Villa Creek (SLO Co.), Cayucos Creek, Old Creek, Toro Creek, Morro Creek, Chorro Creek, Los Osos Creek, Islay Creek, Coon Creek, Diablo Canyon, San Luis Obispo Creek, Pismo Creek, Arroyo Grande Creek

Abundance and Productivity. Historic S-CCC steelhead abundance is unknown. In the mid-1960s, CDFG estimated S-CCC steelhead abundance at 17,750 fish (CDFG 1965). The CDFG estimate, however, is just a midpoint number in the S-CCC steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest and coastal development. Current S-CCC steelhead abundance is still not well known. Multiple short-term studies using different methodologies have occurred over the past decade.

Table 22. Geometric Mean Abundances of S-CCC Steelhead Spawners from 2001-2012 Escapements by Population.

Stratum	Waterbody	Years	Abundance	Expected Number of Outmigrants[a]
Interior Coast Range	**Pajaro River[b]**	2007-2011	35	3,981
	Salinas River[c]	2011-2013	21	2,389
Carmel River Basin	**Carmel River[d]**	2009-2013	318	36,173
Big Sur Coast	**Big Sur River[e]**	2010	11	1,251
	Garrapata Creek[f]	2005	17	1,934
San Luis Obispo Terrace	**Arroyo Grande Creek[g]**	2006	18	2,048
	Chorro Creek[h]	2001	2	228
	Coon Creek[i]	2006	3	341
	Los Osos Creek[h]	2001	23	2,616
	San Simeon Creek[j]	2005	4	455
	Santa Rosa Creek[k]	2002-2006	243	27,641
Total			**695**	**79,057**

[a]Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant
[b]Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoUpercent3D&tabid=1772
[c]Kraft et al. 2013
[d]Sources: http://www.mpwmd.dst.ca.us/fishcounter/fishcounter.htm and http://www.mpwmd.dst.ca.us/wrd/lospadres/lospadres.htm.
[e]Allen and Riley 2012
[f]Garrapata Creek Watershed Council 2006
[g]Source: http://www.coastalrcd.org/zone1-1a/Fisheriespercent20Studies/AG_Steelhead_Report_Draft-small.pdf
[h]Source: http://www.coastalrcd.org/images/cms/files/MBpercent20Steelheadpercent20Abundpercent20andpercent20Distpercent20Report.pdf
[i]City of San Luis Obispo 2006
[j]Baglivio 2012
[k]Stillwater Sciences et al. 2012

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile S-CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. The estimated average adult run size is 695 (Table 22). Juvenile S-CCC steelhead abundance estimates come from the escapement data (Table 22). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 348 females), 1.2 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 79,057 natural outmigrants annually.

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

The Carmel River contains the biggest spawning run of the DPS (Williams et al. 2011). Two dams and reservoirs (Los Padres and San Clemente) are built in the drainage and are monitored for fish abundance. In 2013, the San Clemente dam has begun to be removed, and when completed the Carmel River will be rerouted. While improving steelhead habitat, this will remove one of the few locations where steelhead are monitored within the DPS. The Santa Rosa Creek has the second most abundant run for the DPS, but it is poorly studied. Overall, this steelhead DPS is too data poor for abundance to statistically test abundance trends.

Threats and Limiting Factors. There are several factors and threats that have contributed to the decline of S-CCC steelhead. NMFS (2012a) outlines these as the following: (1) dams, surface water diversions, and groundwater extraction; (2) agricultural and urban development, roads, and other passage barriers; (3) flood control, levees, and channelization; (4) non-native species; (5) estuarine loss; (6) marine environment threats; (7) natural environmental variability; and (8) pesticide use. The principal threats to S-CCC steelhead viability are associated with the four major river systems – the Pajaro, Salinas, Nacimiento/Arroyo Seco, and the Carmel rivers (Williams et al. 2011). Loss of surface flows or other passage impediments along rivers adversely affect upstream tributary productivity, which provide spawning and rearing habitat. Further, dams negatively affect the hydrology, sediment transport processes, and drainage geomorphology (NMFS 2012c). Agricultural development on lower floodplains has resulted in channelization, riparian vegetation removal, and of channel structure simplification, as well as increase fine sediments and other types of pollution (i.e. pesticides, fertilizers). Urban development, in general, is concentrated in the coastal terraces and middle and lower portions of watershed (NMFS 2012c). Flood control practices, associated stream channelization, and levee placement impair stream habitat function and quality (NMFS 2012c). Non-native game fish species have been intentionally introduced (i.e. striped bass) as well as many other non-native species of wildlife and plant species into the watersheds of this DPS, which potentially can displace native species, or adversely affect aquatic habitat conditions (NMFS 2012c). Estuarine environments are important for steelhead development, but approximately 75 percent of the habitat has been lost with the remaining 25 percent impacted by agricultural and urban development, levees, and transportation corridors (NMFS 2012c). Steelhead spend a majority of their lives in the ocean and are impacted by the changes and threats in the marine environment (NMFS 2012c). The S-CCC steelhead reside in a Mediterranean climatic zone, which is characterized by two distinct annual seasons, with a high degree of inter-annual and decadal variability. Freshwater habitat conditions are strongly influenced by the intra- and inter-annual pattern of short-duration cyclonic storms with little snowfall (NMFS 2012c). Pesticides are used extensively for commercial agricultural purposes and can have deleterious effects upon steelhead (NMFS 2012c).

Status Summary. There is little new evidence to indicate that the status of the S-CCC Steelhead DPS has changed appreciably in either direction since the last status review (Williams et al. 2011, Williams et al. 2016), though the Carmel River runs have shown a long term decline, likely exacerbated by the extended drought, and possible the reliance on hatchery reared juvenile *O. mykiss*. The extended drought and the lack of comprehensive monitoring, has also limited the ability to fully assess the status of individual populations and the DPS as whole. The systemic anthropogenic threats identified at the time of the initial listing have remained essentially unchanged over the past 5 years, though there has been significant progress in removing fish passage barriers in a number of the smaller and mid-sized watersheds. Threats to the South-Central California Coast DPS posed by environmental variability resulting from projected climate change are likely to exacerbate the factors affecting the continued existence of the DPS. S-CCC steelhead recovery will require reducing threats to the long-term persistence of wild populations, maintaining multiple interconnected populations of steelhead across the diverse habitats of their native range, and preserving the diversity of steelhead life history strategies that allow the species to withstand natural environmental variability—both intra-annually and over the long-term (NMFS 2012a). Currently, nearly half of this DPS reside in one river – the Carmel River. Most of the other streams and rivers have small populations that can be stochastically driven to extirpation.

2.2.2.10 Southern California Steelhead

Description, Geographic Range. On August 18, 1997, NMFS listed SC steelhead as an endangered species (62 FR 43937). NMFS concluded that the SC steelhead DPS was in danger of extinction throughout all or a significant portion of its range. There is no hatchery production in support of this DPS. The geographic range of the SC steelhead DPS extends from the Santa Maria River, near Santa Maria, to the California–Mexico border, which represents the known southern geographic extent of the anadromous form of *O. mykiss*.

Spatial Structure and Diversity. NMFS described historical and recent steelhead abundance and distribution for the southern California coast through a population characterization (Boughton et al. 2006). Surveys in Boughton et al. (2005) indicate between 58 percent and 65 percent of the historical steelhead basins currently harbor *O. mykiss* populations at sites with connectivity to the ocean. Most of the apparent losses of steelhead were noted in the south, including Orange and San Diego Counties (Boughton et al. 2005).

Abundance and Productivity. While 46 drainages support the SC steelhead DPS (Boughton et al. 2005), only 10 population units possess a high and biologically plausible likelihood of being viable and independent[1] (Boughton et al. 2006). Very little data regarding abundances of

[1] Independent population: a collection of one or more local breeding units whose population dynamics or extinction

Southern California Coast steelhead are available, but the picture emerging from available data suggest very small (<10 fish) but surprisingly consistent annual runs of anadromous fish across the diverse set of basins that are currently being monitored (Williams et al. 2011). The most significant population that has been recently monitored is in Topanga Creek, where mark-recapture studies were done in 2007-2008. According to the authors (Bell et al. 2011), that data indicated a population of resident fish whose abundance is on the order of 500 individuals, including all size and age classes in Topanga Creek. It is believed that population abundance trends can significantly vary based on yearly rainfall and storm events within the range of the Southern California Coast DPS (Williams et al. 2011). A relatively large number of adult steelhead were observed in 2008, two years after an extended wet spring that presumably gave smolts ample opportunity to migrate to the ocean. Some of the strength of the 2008 season may also be an artifact of conditions that year. Low rainfall appears to have caused many spawners to get trapped in freshwater, where they were observed during the summer; in addition, low rainfall probably improved conditions for viewing fish during snorkel surveys, and for trapping fish in weirs (Williams et al. 2011). Much of the data pertaining to the incidence of adult anadromous *O. mykiss* in the SC steelhead DPS is not appropriate to be used to generate abundance estimates. However, the annual presence and count of adult SC steelhead has been documented annually in a number of streams (Table 23).

Table 23. Mean and Total Observations of Adult Anadromous SC Steelhead from 2005 to 2014. (Santa Ynez River Adaptive Management Committee 2009, United States Bureau of Reclamation 2011, Hovey and O'Brien 2013, Dagit et al. 2015, Casitas Municipal Water District (2005 through 2014), United Water Conservation District (2005 through 2014), Mark Capelli unpublished data, George Sutherland unpublished data, Resource Conservation District of the Santa Monica Mountains unpublished data, Mauricio Gomez unpublished data, Dave Katjaniak unpublished data)

		Observations	
System	**Years**	**Total**	**Mean Annual**
Santa Ynez River	2005 - 2014	29	2.9
Ventua River	2006 - 2014	13	1.4
Santa Clara River	2005 - 2014	5	0.5
Goleta Slough	2005 - 2014	6	0.6
Mission Creek	2005 - 2014	18	1.8
Carpinteria Creek	2008	3	-
Conejo Creek	2013	1	-
Malibu Creek	2006 - 2014	23	2.6
Topanga Creek	2005 - 2014	8	0.8
Ballona Creek	2008	2	-
San Juan Creek	2005 - 2014	5	0.5
Santa Margarita Creek	2009	1	-
San Luis Rey River	2007	2	-

risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations (Boughton et al. 2006).

Las Penasquito Creek	2012	1	-
	Total	**117**	**11.1**

There is little new evidence to suggest that the status of the Southern California DPS has changed appreciably in either direction since publication of the most recent collections of status reviews (Good et al. 2005; NMFS 2011d; Williams et al. 2011). The observations of adult SC steelhead for the last ten years of only average around 11 individuals annually (Table 24). However, the most recent SC steelhead recovery plan found no evidence that the annual return of anadromous adults has changed since the original 2005 status review, which estimated the number to be less than 500 individuals (Busby et al. 1996, NMFS 2012d). Given this range of expected annual returning spawners, the most conservative estimate of juvenile production based on those returns would be based on the assumption that the number of returning spawners for the DPS is just 11 fish. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 5.5 females), 19,425 eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce a minimum of 1,262 natural outmigrants annually. This estimate of outmigrants is derived from the most conservative estimate within the range of the abundance estimate of adult anadromous returns, but further complicating this calculation, the SC steelhead DPS is also influenced by the presence of a significant unlisted resident population of *O. mykiss*. Due to the phenotypic plasticity between these two life history strategies that has been demonstrated in *O. mykiss* (Pearse 2009), it is possible that additional outmigrants may be derived from this unlisted resident population, or that some residual offspring of anadromous parents may express a resident life history. For that reason, differentiating anadromous and resident juveniles pre-smoltification is not possible, so for precautionary reasons, all juvenile *O. mykiss* that occur within the SC steelhead range are considered to be SC steelhead.

Threats and Limiting Factors. The majority of lost populations (68 percent) of SC steelhead have been associated with anthropogenic barriers to steelhead migration (e.g., dams, flood-control structures, culverts, etc.). Additionally, investigators have found that barrier exclusions are statistically associated with highly-developed watersheds. SC steelhead populations experience a high magnitude of threat to a small number of extant populations vulnerable to extirpation due to loss of accessibility to freshwater spawning and rearing habitat, low abundance, degraded estuarine habitats and watershed processes essential to maintain freshwater habitats (NMFS 2011d). The practice of fire suppression within the range of this DPS, and the associated potential for increased fire intensity and duration, has also been identified as a potential threat to the steelhead in this DPS (62 FR 43937). The recovery potential is low to moderate due to the lack of additional populations, lack of available/suitable freshwater habitat, steelhead passage barriers, and inadequate instream flow.

Status Summary. There is little new evidence to suggest that the status of the SC steelhead DPS has changed appreciably in either direction since publication of the most recent collections of status reviews (Good et al. 2005; NMFS 2011d; Williams et al. 2011, Williams et al. 2016).

2.2.2.11 Green Sturgeon

Description and Geographic Range. On April 7, 2006, NMFS listed the southern DPS of North American green sturgeon (hereafter referred to as "green sturgeon") as a threatened species (71 FR 17757). The southern DPS consists of coastal and Central Valley populations south of the Eel River (exclusive), with the only known spawning population in the Sacramento River. Information on their oceanic distribution and behavior indicates that green sturgeon make generally northern migrations—even occurring in numbers off Vancouver Island (NMFS 2005b). A mixed stock assessment assigned about 70 to 90 percent of the green sturgeon present in the Columbia River estuary and Willapa Bay to the southern DPS. The stock composition in Grays Harbor is about 40 percent southern DPS (Israel et al. 2009).

Green sturgeon—like all sturgeon—is a long-lived, slow-growing species. Adult green sturgeon typically migrate into fresh water beginning in late February and spawn from March to July. Green sturgeon females produce 60,000-140,000 eggs. Green sturgeon larvae are different from all other sturgeon because they lack a distinct swim-up or post-hatching stage and are distinguished from white sturgeon by their larger size, light pigmentation, and size and shape of the yolk sac. First feeding occurs 10 days after they hatch, and metamorphosis to juveniles is complete at 45 days. The larvae grow fast, reaching a length of 66 mm and a weight of 1.8 grams in three weeks of exogenous feeding. Larvae hatched in the laboratory are photonegative and exhibit hiding behaviors after the onset of exogenous feeding. The larvae and juveniles are nocturnal. Juveniles appear to spend one to three years in freshwater before they enter the ocean (NMFS 2005b).

Green sturgeon disperse widely in the ocean between their freshwater life stages. In the Klamath River, Nakamoto et al. (1995) found a lack of females from ages 3 to 13 and males from ages 3 to 9 suggesting an entirely marine existence during those ages. Green sturgeon reach maturity at 14 years for males and 16 years for females (Van Eenennaam et al. 2006) with maximum ages of 60 to 70 years or longer (Moyle 2002). Mature females return every two to four years to spawn (Erickson and Webb 2007). Lindley et al. (2008) found that green sturgeon make rapid, long distance season migrations along the continental shelf of North America from central California to central British Columbia. In the fall, green sturgeon move northward to or past the northern end of Vancouver Island, stay there for the winter, and then return southward during the spring. In an acoustic transmitter study, Moser and Lindley (2007) found that green sturgeon were routinely detected in Willapa Bay during the summer when estuarine water temperatures were greater than the coastal temperatures. However, green sturgeon were not detected in Willapa Bay during the winter when temperatures were below 10° C.

Spatial Structure and Diversity. Green sturgeon are composed of two DPS with two geographically distinct spawning locations. The northern DPS spawn in rivers north of and including the Eel River in Northern California with known spawning occurring in the Eel, Klamath, and Trinity rivers in California and the Rogue and Umpqua rivers in Oregon. The southern DPS spawn in rivers south of the Eel River which is now restricted to the Sacramento River. Historic spawning grounds were blocked by the construction of Shasta Dam (1938-1945) and Keswick Dam (1941-1950) on the Sacramento River and Oroville Dam (1961-1968) on the Feather River. Spawning grounds became limited to an area downstream of Shasta Dam that was impacted by high temperatures until the construction of a temperature control device in Shasta Dam in 1997 (Adams et al. 2007).

The CDFG reported that Oroville Dam limits access to potential spawning habitat, and warm water releases from the Thermalito Afterbay reservoir may increase temperatures to levels unsuitable for green sturgeon spawning and incubation in the Feather River (CDFG 2002). Adult green sturgeons have also been captured in the San Joaquin River delta (Adams et al. 2002). Moyle et al. (1992) suggested that green sturgeon presence in the delta is evidence that green sturgeon are spawning in the San Joaquin River. But, there are no documented observations of green sturgeon in the San Joaquin River upstream of the delta. Studies done by UC Davis (Mora unpublished data) have revealed that green sturgeon spawning sites are concentrated in just a handful of locations. Mora found that in the Sacramento River, just 3 sites accounted for over 50 percent of the green sturgeon documented in June of 2010, 2011, and 2012. This is a critical point with regards to the application of the spatial structure VSP parameter, which is largely concerned with the spawning habitat spatial structure. Given a high concentration of individuals into just a few spawning sites, extinction risk due to stochastic events would be expected to be increased.

Diversity in sturgeon populations can range in scale from genetic differences within and among populations to complex life-history traits. One of the leading factors affecting the diversity of green sturgeon is the loss of habitat due to impassable barriers such as dams. As described above, several tributaries to the Sacramento River have been blocked and have therefore almost certainly reduced the DPS's diversity. Although this DPS migrates over long distances, its spawning locations are small and have been greatly affected by human activities.

In summary, current scientific understanding indicates that sDPS green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River, and also breeds opportunistically in the Feather River and possibly even the Yuba River. Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent extirpation from the San Joaquin River narrows the habitat usage by the species, offering fewer alternatives to impacts upon any portion of that habitat.

Abundance and Productivity. Since 2006, research conducted and published has enhanced the understanding of Southern green sturgeon biology and life history, including reproductive characteristics (NMFS 2015). Southern green sturgeon typically spawn every three to four years (range two to six years) and primarily in the Sacramento River (Brown 2007; Poytress et al. 2012). Adult Southern green sturgeon enter San Francisco Bay in late winter through early spring and spawn from April through early July, with peaks of activity influenced by factors including water flow and temperature (Heublein et al. 2009; Poytress et al. 2011). Spawning primarily occurs in the cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble or boulder substrate (NMFS 2015). Eggs incubate for a period of seven to nine days and remain near the hatching area for 18 to 35 days prior to dispersing (Van Eenennaam et al. 2001; Deng et al. 2002; Poytress et al. 2012). Based on length of juvenile sturgeon captured in the San Francisco Bay Delta, Southern green sturgeon migrate downstream toward the estuary between 6 months and 2 years of age (Radtke et al. 1966; NMFS 2015).

Since 2010, Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River for Southern green sturgeon have been conducted. Results from these surveys combined with the observed three to four year spawning cycle for Southern green sturgeon resulted in an estimate of 1,348 adults (Table 24; NMFS 2015). There are no estimates for juvenile green sturgeon.

Table 24. Green sturgeon adult spawner numbers from DIDSON surveys in the upper Sacramento River and ESU estimate (NMFS 2015).

Year	Adult green sturgeon	95percent Confidence Interval
2010	164	117 - 211
2011	220	178 - 262
2012	329	272 - 386
2013	338	277 - 399
2014	526	462 - 590
ESU abundance[a]	1,348	824 – 1,872

[a] ESU abundance for Southern green sturgeon numbers calculated from returning spawners in the Sacramento River and the observed spawning three to four year spawning cycle.

Limiting Factors. Many of the principle factors considered when listing Southern DPS green sturgeon as threatened are relatively unchanged (NMFS 2015). Recent studies confirm that the spawning area utilized by Southern green sturgeon is small. Confirmation of Feather River spawning is encouraging and the decommissioning of Red Bluff Diversion Dam and breach of Shanghai Bench makes spawning conditions more favorable, although Southern green sturgeon still encounter impassible barriers in the Sacramento, Feather and other rivers that limit their spawning range. The relationship between altered flows and temperatures in spawning and rearing habitat and Southern green sturgeon population productivity is uncertain. Entrainment as well as stranding in flood diversions during high water events also negatively impact Southern green sturgeon. The prohibition of retention in commercial and recreational fisheries has eliminated a known threat and likely had a very positive effect on the overall population, although recruitment indices are not presently available (NMFS 2015).

Status Summary. The southern DPS of North American green sturgeon remains vulnerable due to having only one small spawning population, potential growth-limiting and lethal temperatures, harvest concerns, loss of spawning habitat, and entrainment by water projects. There will have to be substantial changes in this species' status before it can recover.

2.2.2.12 Eulachon

Description and Geographic Range. We listed the southern Distinct Population Segment (DPS) of Pacific eulachon (hereafter, "eulachon") as a threatened on March 16, 2010 (75 FR 13012) and confirmed its status as threatened in 2016 (81 FR 33468). We define the DPS as "eulachon originating from the Skeena River in British Columbia south to and including the Mad River in northern California (79 FR 20802).

In May of 2011, the Committee on the Status for Endangered Wildlife in Canada (COSEWIC) released their assessment and status report for eulachon in Canada. COSEWIC divided the Canadian portion of the US designated Southern DPS into three designatable units (DUs) – Nass/Skeena Rivers population, Central Pacific Coast population, and Fraser River population (COSEWIC 2011a). DUs are discrete evolutionarily significant units, where "significant" means that the unit is important to the evolutionary legacy of the species as a whole and if lost would likely not be replaced through natural dispersion (COSEWIC 2009). Thus, DUs are biologically similar to ESU and DPS designations under the ESA. The Fraser River population (the closest Canadian population to the conterminous U.S.) was assessed as endangered by COSEWIC, and the listing decision for the Species at Risk Act (SARA) registry is currently scheduled for 2014 or later (COSEWIC 2011b).

Eulachon are endemic to the northeastern Pacific Ocean; they range from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. Puget Sound lies between two of the larger eulachon spawning rivers (the Columbia and Fraser rivers) but lacks a regular eulachon run of its own (Gustafson et al. 2010). Within the conterminous U.S., most eulachon production originates in the Columbia River basin and the major and most consistent spawning runs return to the Columbia River mainstem and Cowlitz River. Adult eulachon have been found at several Washington and Oregon coastal locations, and they were previously common in Oregon's Umpqua River and the Klamath River in northern California. Runs occasionally occur in many other rivers and streams but often erratically, appearing in some years but not in others and only rarely in some river systems (Hay and McCarter 2000, Gustafson et al. 2010). Since 2005, eulachon in spawning condition have been observed nearly every year in the Elwha River by Lower Elwha Tribe Fishery Biologists (Lower Elwha Tribe, 2011). The Elwha is the only river in the United States' portion of Puget Sound and the Strait of Juan de Fuca that supports a consistent eulachon run.

Eulachon generally spawn in rivers fed by either glaciers or snowpack and that experience spring freshets. Since these freshets rapidly move eulachon eggs and larvae to estuaries, it is believed that eulachon imprint and home to an estuary into which several rivers drain rather than individual spawning rivers (Hay and McCarter 2000). From December to May, eulachon typically enter the Columbia River system with peak entry and spawning during February and March (Gustafson et al. 2010). They spawn in the lower Columbia River mainstem and multiple tributaries of the lower Columbia River.

Eulachon eggs, averaging 1 mm in size, are commonly found attached to sand or pea-sized gravel, though eggs have been found on a variety of substrates, including silt, gravel-to-cobble sized rock, and organic detritus (Smith and Saalfeld 1955, Langer et al. 1977, Lewis et al. 2002). Eggs found in areas of silt or organic debris reportedly suffer much higher mortality than those found in sand or gravel (Langer et al. 1977). Length of incubation ranges from about 28 days in 4°-5° C waters to 21-25 days in 8° C waters. Upon hatching, stream currents rapidly carry the newly hatched larvae, 4-8 mm in length, to the sea. Young larvae are first found in the estuaries of known spawning rivers and then disperse along the coast. After yolk sac depletion, eulachon larvae acquire characteristics to survive in oceanic conditions and move off into open marine environments as juveniles. Eulachon return to their spawning river at ages ranging from two to five years as a single age class. Prior to entering their spawning rivers, eulachon hold in brackish waters while their bodies undergo physiological changes in preparation for fresh water and to synchronize their runs. Eulachon then enter the rivers, move upstream, spawn, and die to complete their semelparous life cycle (COSEWIC 2011a).

Adult eulachon weigh an average of 40 g each and are 15 to 20 cm long with a maximum recorded length of 30 cm. They are an important link in the food chain between zooplankton and larger organisms. Small salmon, lingcod, white sturgeon, and other fish feed on small larvae near river mouths. As eulachon mature, a wide variety of predators consume them (Gustafson et al. 2010).

On September 6, 2017, we published the final recovery plan for eulachon (NMFS 2017).

Spatial Structure and Diversity. There are no distinct differences among eulachon throughout the range of the southern DPS. However, the eulachon Biological Review Team (BRT) did separate the DPS into four subpopulations in order to rank threats they face. These are the Klamath River (including the Mad River and Redwood Creek), the Columbia River (including all of its tributaries), the Fraser River, and the BC coastal rivers (north of the Fraser River up to, and including, the Skeena River). Eulachon population structure has not been analyzed below the DPS level. The COSEWIC assessed eulachon populations in Canada and designated them with the following statuses: Nass/Skeena Rivers population (threatened), Central Pacific population (endangered), and Fraser River population (endangered) (COSEWIC 2011a).

Eulachon of the southern DPS are distinguished from eulachon occurring north of the DPS range by a number of factors including genetic characteristics. Significant microsatellite DNA variation in eulachon has been reported from the Columbia River to Cook Inlet, Alaska (Beacham et al. 2005). Within the range of the southern DPS, Beacham et al. (2005) found genetic affinities among the populations in the Fraser, Columbia, and Cowlitz rivers and also among the Kemano, Klinaklini, and Bella Coola rivers along the central British Columbia coast. In particular, there was evidence of a genetic discontinuity north of the Fraser River, with Fraser and Columbia/Cowlitz samples diverging three to six times more from samples further to the north than they did from each other. Similar to the study of McLean et al. (1999), Beacham et al. (2005) found that genetic differentiation among populations was correlated with geographic distances. The authors also suggested that the pattern of eulachon differentiation was similar to that typically found in studies of marine fish, but less than that observed in most salmon species.

The BRT was concerned about risks to eulachon diversity due to its semelparity (spawn once and die) and data suggesting that Columbia and Fraser River spawning stocks may be limited to a single age class. These characteristics likely increase their vulnerability to environmental catastrophes and perturbations and provide less of a buffer against year-class failure than species such as herring that spawn repeatedly and have variable ages at maturity (Gustafson et al. 2010).

Abundance and Productivity. Eulachon are a short-lived, high-fecundity, high-mortality forage fish; and such species typically have extremely large population sizes. Fecundity estimates range from 7,000 to 60,000 eggs per female with egg to larva survival likely less than 1 percent (Gustafson et al. 2010). Among such marine species, high fecundity and mortality conditions may lead to random "sweepstake recruitment" events where only a small minority of spawning individuals contribute to subsequent generations (Hedgecock 1994).

Prior to 2011, few direct estimates of eulachon abundance existed. Escapement counts and spawning stock biomass estimates are only available for a small number of systems. Catch statistics from commercial and First Nations fisheries are available for some systems in which no direct estimates of abundance are available. However, inferring population status or even trends from yearly catch statistic changes requires making certain assumptions that are difficult to corroborate (e.g., assuming that harvest effort and efficiency are similar from year to year, assuming a consistent relationship among the harvested and total stock portion, and certain statistical assumptions, such as random sampling). Unfortunately, these assumptions cannot be verified, few fishery-independent sources of eulachon abundance data exist, and in the United States, eulachon monitoring programs just started in 2011. However, the combination of catch records and anecdotal information indicates that there were large eulachon runs in the past and that eulachon populations have severely declined (Gustafson et al. 2010). As a result, eulachon numbers are at, or near, historically low levels throughout the range of the southern DPS.

Similar abundance declines have occurred in the Fraser and other coastal British Columbia rivers (Hay and McCarter 2000, Moody 2008). Over a three-generation time of 10 years (1999-2009), the overall Fraser River eulachon population biomass has declined by nearly 97 percent (Gustafson et al. 2010). In 1999, the biomass estimates were 418 metric tons[2]; and by 2010, had dropped to just 4 metric tons (Table 25). Abundance information is lacking for many coastal British Columbia subpopulations, but Gustafson et al. (2010) found that eulachon runs were universally larger in the past. Furthermore, the BRT was concerned that four out of seven coastal British Columbia subpopulations may be at risk of extirpation as a result of small population concerns such as Allee[3] effects and random genetic and demographic effects (Gustafson et al. 2010). Under SARA, Canada designated the Fraser River population as endangered in May 2011 due to a 98 percent decline in spawning stock biomass over the previous 10 years (COSEWIC 2011a). From 2013 through 2017, the Fraser River eulachon spawner population estimate is 1,968,688 adults (Table 25).

[2] The U.S. ton is equivalent to 2,000 pounds and the metric ton is equivalent to 2,204 pounds.

[3] The negative population growth observed at low population densities. Reproduction—finding a mate in particular— for migratory species can be increasingly difficult as the population density decreases.

Table 25. Southern DPS eulachon spawning estimates for the lower Fraser River, British Columbia (data from http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/river1-eng.html).

Year	Biomass estimate (metric tons)	Estimated spawner population[a]
2008	10	246,918
2009	14	345,685
2010	4	98,767
2011	31	765,445
2012	120	2,963,013
2013	100	2,469,177
2014	66	1,629,657
2015	317	7,827,292
2016	44	1,086,438
2017	35	864,211
2013-2017[b]	**80**	**1,968,688**

[a] Estimated population numbers are calculated as 11.2 eulachon per pound.
[b] Five-year geometric mean of eulachon biomass estimates (2013-2017).

The Columbia River and its tributaries support the largest known eulachon run. Although direct estimates of adult spawning stock abundance are limited, commercial fishery landing records begin in 1888 and continue as a nearly uninterrupted data set to 2010 (Gustafson et al. 2010). From about 1915 to 1992, historic commercial catch levels were typically more than 500 metric tons, occasionally exceeding 1,000 metric tons. In 1993, eulachon catch levels began to decline and averaged less than five metric tons from 2005-2008 (Gustafson et al. 2010). Persistent low eulachon returns and landings in the Columbia River from 1993 to 2000 prompted the states of Oregon and Washington to adopt a Joint State Eulachon Management Plan (WDFW and ODFW 2001). From 2011 through 2013, all recreational and commercial fisheries for eulachon were closed in Washington and Oregon; but the fisheries were reopened in 2014. Beginning in 2011, ODFW and Washington Department of Fish and Wildlife (WDFW) began eulachon biomass surveys similar to those conducted on the Fraser River. From 2013 through 2015, eulachon abundance increased with a peak of over 84.2 million eulachon spawners in 2014. Since that 2014 peak, eulachon numbers have decreased annually with the lowest spawner run total, since the surveys began in 2011, of 8.15 million in 2017 (Langness 2017). From 2013 through 2017, the estimated eulachon spawner estimate for the Columbia River and its tributaries is 75,629,327 eulachon spawning adults (Table 26).

Table 26. Annual Columbia River eulachon run size 2000-2017; pounds converted to numbers of fish at 11.16 fish/pound (WDFW and ODFW 2016). The estimates were calculated based on methods developed by Parker (1985), Jackson and Cheng (2001), and Hay et al. (2002) to estimate spawning biomass of pelagic fishes. For 2000 through 2010 estimates were back-calculated using historical larval density data.

Year	Maximum Estimates	Mean Estimates	Minimum Estimates
2000	8,971,500	5,421,500	3,205,200
2001	128,960,500	77,512,900	35,121,600
2002	76,645,800	59,114,500	42,541,900
2003	99,395,400	64,670,000	45,137,700
2004	—	—	—
2005	1,450,800	783,400	226,500
2006	3,527,700	1,233,200	387,300
2007	3,272,100	1,605,900	863,800
2008	6,510,700	2,418,400	713,100
2009	10,034,000	4,873,600	1,984,200
2010	4,281,000	1,759,900	612,700
2011	69,661,800	36,775,900	17,860,400
2012	61,437,400	35,722,100	20,008,600
2013	197,943,400	107,794,900	45,546,700
2014	323,778,300	185,965,200	84,243,100
2015	207,570,500	123,582,000	57,525,700
2016	111,991,000	54,556,500	21,654,800
2017	34,071,100	18,307,100	8,148,600
2013-2017[a]	**138,390,008**	**75,629,327**	**32,968,415**

[a] Five-year geometric mean of eulachon biomass estimates (2013-2017).

In Northern California, no long-term eulachon monitoring programs exist. In the Klamath River, large eulachon spawning aggregations once regularly occurred but eulachon abundance has declined substantially (Fry 1979, Moyle et al. 1995, Larson and Belchik 1998, Hamilton et al. 2005). Recent reports from Yurok Tribal fisheries biologists mentioned only a few eulachon captured unintentionally in other fisheries.

Beacham et al. (2005) reported that marine sampling by trawl showed that eulachon from different rivers mix during their 2 to 3 years of pre-spawning life in offshore marine waters, but not thoroughly. Their samples from southern British Columbia comprised a mix of fish from multiple rivers, but were dominated by fish from the Columbia and Fraser River populations. The combined estimate from the Columbia and Fraser rivers is 77.60 million eulachon.

Limiting Factors. Climate change impacts on ocean habitat are the most serious threat to persistence of the southern DPS of eulachon (Gustafson et al. 2010), thus it will be discussed in greater detail in this section. Scientific evidence strongly suggests that global climate change is already altering marine ecosystems from the tropics to polar seas. Physical changes associated with warming include increases in ocean temperature, increased stratification of the water column, and changes in the intensity and timing of coastal upwelling. These changes will alter primary and secondary productivity and the structure of marine communities (ISAB 2007).

Although the precise changes in ocean conditions cannot be predicted they present a potentially severe threat to eulachon survival and recovery. Increases in ocean temperatures have already occurred and will likely continue to impact eulachon and their habitats. In the marine environment, eulachon rely upon cool or cold ocean regions and the pelagic invertebrate communities therein (Wilson et al. 2006). Warming ocean temperatures will likely alter these communities, making it more difficult for eulachon and their larvae to locate or capture prey (Roemmich and McGowan 1995, Zamon and Welch 2005). Warmer waters could also allow for the northward expansion of eulachon predator and competitor ranges, increasing the already high predation pressure on the species (Rexstad and Pikitch 1986, McFarlane et al. 2000, Phillips et al. 2007).

Climate change along the entire Pacific Coast is expected to affect fresh water as well. Changes in hydrologic patterns may pose challenges to eulachon spawning because of decreased snowpack, increased peak flows, decreased base flow, changes in the timing and intensity of stream flows, and increased water temperatures (Morrison et al. 2002). In most rivers, eulachon typically spawn well before the spring freshet, near the seasonal flow minimum. This strategy typically results in egg hatch coinciding with peak spring river discharge. The expected alteration in stream flow timing may cause eulachon to spawn earlier or be flushed out of spawning rivers at an earlier date. Early emigration may result in a mismatch between entry of larval eulachon into the ocean and coastal upwelling, which could have a negative impact on marine survival of eulachon during this critical transition period (Gustafson et al. 2010).

In the past, commercial and recreational harvests likely contributed to eulachon decline. The best available information for catches comes from the Columbia River, where from 1938 to 1993 landings have averaged almost 2 million pounds per year (approximately 24.6 million fish), and have been as high as 5.7 million pounds in a single year (approximately 70 million fish) (Wydoski and Whitney 2003, Gustafson et al. 2010). Between 1994 and 2010, no catch exceeded one million pounds (approximately 12.3 million fish) annually and the median catch was approximately 43,000 pounds (approximately 529,000 fish), which amounts to a 97.7 percent reduction in catch (WDFW and ODFW 2001, JCRMS 2011). Catch from recreational eulachon fisheries was also high historically (Wydoski and Whitney 2003); and at its height in popularity, the fishery would draw thousands of participants annually. Currently, commercial and recreational harvest of eulachon is prohibited in both Washington and Oregon.

In British Columbia, the Fraser River supports the only commercial eulachon fishery that is within the range of the southern DPS. This fishery has been essentially closed since 1997, only opening briefly in 2002 and 2004 when only minor catches were landed (DFO 2008).

Historically, bycatch of eulachon in the pink shrimp fishery along the U.S. and Canadian coasts has been very high (composing up to 28 percent of the total catch by weight; Hay and McCarter 2000, DFO 2008). Prior to the mandated use of bycatch-reduction devices (BRDs) in the pink shrimp fishery, 32–61 percent of the total catch in the pink shrimp fishery consisted of non-shrimp biomass, made up mostly of Pacific hake, various species of smelt including Pacific eulachon, yellowtail rockfish, sablefish, and lingcod (*Ophiodon elongatus*) (Hannah and Jones 2007). Reducing bycatch in this fishery has long been an active field of research (Hannah et al. 2003, Hannah and Jones 2007, Frimodig 2008) and great progress has been made in reducing bycatch. As of 2005, following required implementation of BRDs, the total bycatch by weight had been reduced to about 7.5 percent of the total catch and osmerid smelt bycatch was reduced to an estimated average of 0.73 percent of the total catch across all BRD types (Hannah and Jones 2007). Despite this reduction, bycatch of eulachon in these fisheries is still significant. The total estimated bycatch of eulachon in the Oregon and California pink shrimp fisheries ranged from 217,841 fish in 2004 to 1,008,260 fish in 2010 (the most recent year that data is available; Al-Humaidhi et al. 2012).

Hydroelectric dams block access to historical eulachon spawning grounds and affect the quality of spawning substrates through flow management, altered delivery of coarse sediments, and siltation. Dredging activities during the eulachon spawning run may entrain and kill adult and larval fish and eggs. Eulachon carry high levels of pollutants – arsenic, lead, mercury, DDE, 9H-Fluorene, Phenanthrene (EPA 2002), and although it has not been demonstrated that high contaminant loads in eulachon have increased mortality or reduced reproductive success, such effects have been shown in other fish species (Kime 1995). The negative effects of these factors on the species and its habitat contributed to the determination to list the southern DPS of Pacific eulachon under the ESA.

Status Summary. Adult spawning abundance of the southern DPS of eulachon has clearly increased since the listing occurred in 2010 (Gustafson et al. 2016). The improvement in estimated abundance in the Columbia River, relative to the time of listing, reflects both changes in biological status and improved monitoring. The documentation of eulachon returning to the Naselle, Chehalis, Elwha, and Klamath rivers over the 2011–2015 also likely reflects both changes in biological status and improved monitoring. The Biological Review Team (BRT) concluded that, starting in 1994, the southern DPS of eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Although eulachon abundance in monitored rivers improved in the 2013–2015 return years, recent conditions in the northeast Pacific Ocean are likely linked to the sharp declines in eulachon abundance in monitored rivers in 2016 and 2017. The likelihood that these poor ocean conditions will persist into the near future suggest that subpopulation declines may again be widespread in the upcoming return years (NMFS 2017).[4] Since the 2014 eulachon spawner peak, eulachon runs have decreased each year with the 2017 Columbia River run being the smallest since the eulachon surveys began in 2011 (pers. comm., R. Gustafson, June 8, 2017).

[4] National Marine Fisheries Service. September 2017. Recovery Plan for the Southern Distinct Population Segment of Eulachon (Thaleichthys pacificus). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232.

2.2.3 Status of the Species' Critical Habitats

Due to the nature of the proposed research activities the section below describes the status of critical habitat in the most general terms. That is, because the proposed activities are so widespread and, by their nature, do not disturb land features, it is not necessary to go into great detail about that habitat's status (unlike the species status).

2.2.3.1 Salmon ESUs and Steelhead DPSs

We review the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated area. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code in terms of the conservation value they provide to each listed species they support[5]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs; NMFS 2005) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

The physical or biological features of freshwater spawning and incubation sites, include water flow, quality and temperature conditions and suitable substrate for spawning and incubation, as well as migratory access for adults and juveniles. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring. The physical or biological features of freshwater migration corridors associated with spawning and incubation sites include water flow, quality and temperature conditions supporting larval and adult mobility, abundant prey items supporting larval feeding after yolk sac depletion, and free passage (no

[5] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NMFS 2005).

obstructions) for adults and juveniles. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas and they allow larval fish to proceed downstream and reach the ocean.

As noted previously, the designations of critical habitat for species used the terms primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat

Central Valley Spring-run Chinook Salmon. Critical habitat was designated for CVSR Chinook salmon on September 2, 2005, when NMFS published a final rule in the *Federal Register* (70 FR 52488).

CVSR Chinook salmon PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. NMFS determined that marine areas did not warrant consideration as critical habitat for this ESU. There are approximately 1,373 miles of stream habitats and 427 square miles of estuary habitats designated as critical habitat for CVSR Chinook salmon in 37 watersheds. The CHART rated seven watersheds as having low, three as having medium, and 27 as having high conservation value to the ESU. Four of these watersheds comprise portions of the San Francisco-San Pablo-Suisun Bay estuarine complex, which provides rearing and migratory habitat for the ESU. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

Sacramento River winter-run Chinook salmon. Critical habitat was originally designated for SRWR Chinook salmon on June 16, 1993 (58 FR 33212), and then was redesignated and amended on March 23, 1999 (64 FR 14067). Critical habitat includes the following waterways, bottom and water of the waterways and adjacent riparian zones: The Sacramento River from Keswick Dam, Shasta County (RK 486) to Chipps Island (RK 0) at the westward margin of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. The critical habitat for this species was designated before we had implemented the CHART team process, and watersheds have not yet been evaluated for conservation value according to the CHART process. So we examine effects on an individual basis where possible and make case-by-case judgements about the habitat's conservation value. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

California Coastal Chinook Salmon. Critical habitat was designated for CC Chinook salmon on September 2, 2005, when NMFS published a final rule in the *Federal Register* (70 FR 52488). There are approximately 1,475 miles of stream habitats and 25 square miles of estuary habitats designated as critical habitat for CC Chinook salmon. NMFS determined that marine areas did not warrant consideration as critical habitat for this ESU.

CC Chinook salmon PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 45 watersheds within the range of this ESU. Eight watersheds received a low rating, 10 received a medium rating, and 27 received a high rating of conservation value to the ESU. Two estuarine habitat areas used for rearing and migration (Humboldt Bay and the Eel River Estuary) also received a high conservation value rating. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

Southern Oregon/Northern California Coast Coho Salmon. Critical habitat was designated for SONCC coho salmon on May 5, 1999 (64 FR 24049). Critical habitat includes all river reaches accessible to listed coho salmon in coastal streams south of Cape Blanco, Oregon, and north of Punta Gorda, California.

Critical habitat consists of the water, substrate, and adjacent riparian zone of estuarine and riverine reaches (including off-channel habitats) in the following Counties: Klamath, Jackson, Douglas, Josephine, and Curry in Oregon, and Humboldt, Mendocino, Trinity, Glenn, and Del Norte in California. Major rivers, estuaries, and bays known to support SONCC coho salmon include the Rogue River, Smith River, Klamath River, Mad River, Humboldt Bay, Eel River, and Mattole River. Many smaller coastal rivers and streams also provide essential estuarine habitat for coho salmon, but access is often constrained by seasonal fluctuations in hydrologic conditions. Within these areas, essential features of coho salmon critical habitat include adequate; (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

Central California Coast Coho Salmon. Critical habitat was designated for CCC coho salmon on May 5, 1999 (64 FR 24049). Critical habitat for the CCC coho salmon ESU encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between Punta Gorda and the San Lorenzo River (inclusive) in California, including two streams entering San Francisco Bay: Arroyo Corte Madera Del Presidio and Corte Madera Creek. Critical habitat includes all waterways, substrate, and adjacent riparian zones below longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). NMFS has identified several dams in the CCC coho salmon critical habitat range that currently block access to habitats historically occupied by coho salmon. However, NMFS has not designated these inaccessible areas as critical habitat because the downstream areas are believed to provide sufficient habitat for conserving the ESUs. The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

California Central Valley Steelhead. Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). There are approximately 2,308 miles of stream habitats and 254 square miles of estuary habitats designated as critical habitat for CCV steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

CCV steelhead PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 67 watersheds within the range of this DPS. Twelve watersheds received a low rating, 18 received a medium rating, and 37 received a high rating of conservation value to the DPS. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

Northern California Steelhead. Critical habitat was designated for NC steelhead on September 2, 2005 (70 FR 52488). There are approximately 3,028 miles of stream habitats and 25 square miles of estuary habitats designated as critical habitat for NC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

NC steelhead PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 50 watersheds within the range of this DPS. Nine watersheds received a low rating, 14 received a medium rating, and 27 received a high rating of conservation value to the DPS. Two estuarine habitats, Humboldt Bay and the Eel River estuary, received a high conservation value rating.

NC steelhead inhabit coastal river basins from Redwood Creek south to, and including, the Gualala River. Major watersheds include Redwood Creek, Mad River, Eel River, and several smaller coastal watersheds southward to the Gualala River. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

Central California Coast Steelhead. Critical habitat was designated for CCC steelhead on September 2, 2005 (70 FR 52488). There are approximately 1,465 miles of stream habitats and 386 square miles of estuary habitats designated as critical habitat for CCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

CCC steelhead PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 46 watersheds within the range of this DPS. Fourteen watersheds received a low rating, 13 received a medium rating, and 19 received a high rating of conservation value to the DPS. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

South-Central California Coast Steelhead. Critical habitat was designated for S-CCC steelhead on September 2, 2005 (70 FR 52488). There are approximately 1,249 miles of stream habitats and three square miles of estuary habitats designated as critical habitat for S-CCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

S-CCC steelhead PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 30 watersheds within the range of this DPS. Six watersheds received a low rating, 11 received a medium rating, and 13 received a high rating of conservation value to the DPS. Morro Bay, an estuarine habitat, is used as rearing and migratory habitat for spawning and rearing steelhead. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

S-CCC steelhead inhabit coastal river basins from the Pajaro River south to, but not including, the Santa Maria River. Major watersheds include Pajaro River, Salinas River, Carmel River, and numerous smaller rivers and streams along the Big Sur coast and southward. Only winter-run steelhead are found in this DPS. The climate is drier and warmer than in the north that is reflected in vegetation changes from coniferous forests to chaparral and coastal scrub. The mouths of many rivers and streams in this DPS are seasonally closed by sand berms that form during the low stream flows of summer.

Southern California Steelhead. Critical habitat was designated for SC steelhead on September 2, 2005 (70 FR 52488). There are approximately 708 miles of stream habitats designated as critical habitat for SC steelhead. NMFS determined that no estuary habitats warranted designation as critical habitat, and that marine areas did not warrant consideration as critical habitat for this DPS.

SC steelhead PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 32 watersheds within the range of this DPS. Five watersheds received a low rating, six received a medium rating, and 21 received a high rating of conservation value to the DPS. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

2.2.3.2 Green Sturgeon

Critical habitat was designated for green sturgeon on October 9, 2009 (74 FR 52300). We designated approximately 320 miles of freshwater river habitat, 897 square miles of estuarine habitat, 11,421 square miles of marine habitat, 487 miles of habitat in the Sacramento-San Joaquin Delta, and 135 square miles of habitat in the Yolo and Sutter bypasses (Sacramento River, California) as critical habitat for the sDPS of green sturgeon. Of the areas considered for critical habitat, the Critical Habitat Review Team rated 18 areas as having high, twelve as having medium, and eleven as having low rating for their conservation value to the DPS (NMFS 2009). Areas designated for critical habitat include coastal United States marine waters within 60 fathoms depth from Monterey Bay, California north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the lower Columbia River estuary; and certain coastal bays and estuaries in Washington (Willapa Bay and Grays Harbor).

Based on the best available scientific information, we identified PBFs for freshwater riverine systems, estuarine areas, and nearshore marine waters (74 FR 52300). For freshwater riverine systems, the specific PBFs for species conservation are (1) food resources, (2) substrate type or size, (3) water flow, (4) water quality, (5) migratory corridor, (6) water depth, and (7) sediment quality. For estuarine areas, the specific PBFs for species conservation are (1) food resources, (2) water flow, (3) water quality, (4) migratory corridor, (5) water depth, and (6) sediment quality. For coastal marine areas, the specific PBFs for species conservation are (1) migratory corridor, (2) water quality, and (3) food resources.

From analyses of the identified PBFs and examination of economic activities, NMFS verified that at least one activity in each specific area may threaten at least one PBF such that special management considerations or protection may be required (NMFS 2009). Major categories of habitat-related activities include: (1) dams, (2) water diversions, (3) dredging and disposal of dredged material, (4) in-water construction or alterations, (5) National Pollutant Discharge Elimination System activities and activities generating non-point source pollution, (6) power plants, (7) commercial shipping, (8) aquaculture, (9) desalination plants, (10) proposed alternative energy hydrokinetic projects, (11) Liquefied Natural Gas projects, (12) habitat restoration, and (13) bottom trawl fisheries.

2.2.3.3 Eulachon

We designated critical habitat for eulachon on October 20, 2011 (76 FR 65324). Critical habitat for eulachon includes 16 specific areas in California, Oregon, and Washington. The designated areas are a combination of freshwater creeks and rivers and their associated estuaries, comprising approximately 335 miles of habitat. In our biological report, we found that all of the areas considered for critical habitat designation have a high conservation value. The designated critical habitat areas contain at least one of the following physical and biological features essential to conservation of the species: (1) freshwater spawning and incubation sites; (2) freshwater and estuarine migration corridors; and (3) nearshore and offshore marine foraging sites. Freshwater spawning and incubation sites are essential for successful spawning and offspring production; essential environmental components include specific water flow, quality, and temperature conditions; spawning and incubation substrates; and migratory access. Freshwater and estuarine migration corridors, associated with spawning and incubation sites, are essential for allowing adult fish to swim upstream to reach spawning areas and allowing larval fish to proceed downstream and reach the ocean. Essential environment components include waters free of obstruction; specific water flow, quality, and temperature conditions (for supporting larval and adult mobility), and abundant prey items (for supporting larval feeding after the yolk sac depletion). Nearshore and offshore marine foraging habitat are essential for juvenile and adult survival; essential environmental components include water quality and available prey.

We identified a number of activities that may affect the physical and biological features essential to the southern DPS of eulachon such that special management considerations or protection may be required. Major categories of such activities include: (1) Dams and water diversions; (2) dredging and disposal of dredged material; (3) inwater construction or alterations; (4) pollution and runoff from point and non-point sources; (5) tidal, wind, or wave energy projects; (6) port and shipping terminals; and (7) habitat restoration projects. All of these activities may have an effect on one or more of the essential physical and biological features via their alteration of one or more of the following: stream hydrology; water level and flow; water temperature; dissolved oxygen; erosion and sediment input/transport; physical habitat structure; vegetation; soils; nutrients and chemicals; fish passage; and estuarine/marine prey resources.

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The permitted research activities would take place throughout much of California. Because the proposed activities are so wide-ranging, the action area for this opinion encompasses the entire ranges of all 12 threatened and endangered fish species in California, including all coastal streams from the Oregon/California border, south to San Mateo Creek (San Mateo County), and all anadromous streams of the Sacramento and San Joaquin river basins. The action area is thus spread out a great deal across the landscape. It is also discontinuous. That is, there are large areas in between the various actions' locations where listed salmonids do exist, but where they would not be affected to any degree by any of the proposed activities. In addition, there is one geographically distant outlier that must be included in the action area: that portion of the Puget Sound and Strait of Juan de Fuca inhabited by SR killer whales. As noted earlier, the proposed research activities could affect the killer whales' prey base (Chinook salmon) and so it is possible that some of the actions' effects could be felt as far as hundreds of miles away from where the actual activities would take place. Those effects are described in the Not Likely to Adversely Affect section (2.11).

In all cases, the proposed research activities would take place in individually very small sites. For example, the researchers might electrofish a few hundred feet of river, deploy a beach seine covering only a few hundred square feet of stream, or operate a screw trap in a few tens of square feet of habitat. All of the permitted activities would take place in designated critical habitat.

2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The environmental baseline for this opinion is therefore the result of the impacts that many activities (summarized below) have had on the various listed species' survival and recovery. It is also the result of the effects that climate change has had in the region (see Section 2.2.1 for discussion). Because the action area under consideration covers a large percentage of the listed species' ranges (see Section 2.3), the effects of these past activities on the species themselves (i.e., on their abundance, productivity, etc.) are largely described in the species status sections that precede this section (see Section 2.2). That is, for some of the work being contemplated here, the impacts of activities in the action area are indistinguishable from those effects described in the previous section on the species' rangewide status. Thus, with respect to the species' habitat, the environmental baseline is the combination of these effects on the PBFs that are essential to the conservation of the species. However, in those instances where the action area can be narrowed for a more specific analysis, the baseline in those areas will be taken fully into account.

2.4.1 Summary for all Listed Species

Factors Limiting Recovery

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids. NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). These include habitat degradation caused by human development and harvest and hatchery practices. Climate change also represents a potentially significant threat to all listed species. Climate change effects in the action area are as described in Section 2.2.1. Table 27 is a summary of the major factors limiting recovery of the species considered in this opinion; more details can also be found in the individual discussions of the species' status. Neither the document referenced in Table 27 nor any document referenced in previous sections identifies scientific research as either a cause for any species' decline or a factor preventing its recovery.

Table 27. Major Factors Limiting Recovery (Adapted from NOAA, NMFS, 2011 Report to Congress: Pacific Coast Salmon Recovery Fund FY 2000-2010, accessed at http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/pcsrf/pcsrf-rpt-2011.pdf).

	Estuarine and Nearshore Marine	Floodplain Connectivity and Function	Channel Structure and Complexity	Riparian Areas and Large Woody Debris Recruitment	Stream Substrate	Stream Flow	Water Quality	Fish Passage	Hatchery-related Adverse Effects	Harvest-related Adverse Effects	Predation/Competition/ Disease
CVSR Chinook Salmon	•	•	•	•	•	•	•	•	•	•	•
SRWR Chinook Salmon	•	•	•	•	•	•	•	•	•	•	•
CC Chinook Salmon	•	•	•	•	•	•	•				
SONCC Coho Salmon	•	•	•	•		•	•	•			
CCC coho salmon	•	•	•	•	•	•	•				•
CCV steelhead	•	•	•	•	•	•	•	•	•		•
NC Steelhead	•	•	•	•	•	•	•				•
CCC Steelhead	•	•	•	•	•	•	•	•			•
S-CCC Steelhead	•	•	•	•	•	•	•	•			
SC steelhead	•	•	•	•	•	•	•	•			•
sDPS Green Sturgeon	•	•	•		•	•	•	•			
sDPS Eulachon					•		•	•		•	•

Research Effects

Although they have never been identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids, green sturgeon and eulachon. Several dozen section 10(a)(1)(A) scientific research permits in California authorize lethal and non-lethal take if listed species. In addition, NMFS has also re-authorized the California state scientific research programs under ESA section 4(d) (NMFS Consultation Number: WCR-2017-8530). Table 28 below shows the total take NMFS has authorized for the ongoing research under the ESA sections 10(a)(1)(A) and 4(d).

Table 28. Total Section 10(a)(1)(A) and Section 4(d) Authorized Take of Salmon ESUs and Steelhead DPSs for Scientific Research and Monitoring in 2018.

DPS/ESU	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
CVSR Chinook salmon				
Natural-origin	679	22	865,277	16,740
Listed Hatchery Adipose Clip	682	252	17,028	2,906
SRWR Chinook salmon				
Natural-origin	261	11	175,481	4,987
Listed Hatchery Adipose Clip	187	53	11,533	1,445
CC Chinook salmon				
Natural-origin	930	35	289,064	3,440
SONCC coho salmon				
Natural-origin	1,458	25	179,517	2,489
Listed Hatchery Intact Adipose	1,520	16	7,850	706
Listed Hatchery Adipose Clip	599	11	1,496	44
CCC coho salmon				
Natural-origin	1,703	26	135,861	3,024
Listed Hatchery Adipose Clip/Intact Adipose*	257	10	75,871	1,764
CCV steelhead				
Natural-origin	3,196	87	60,743	1,980
Listed Hatchery Adipose Clip	2,185	100	11,988	836
NC steelhead				
Natural-origin	3,033	14	267,075	4,329
CCC steelhead				
Natural-origin	2,348	36	193,111	4,445
Listed Hatchery Adipose Clip	1,377	26	208,089	4,973
S-CCC steelhead				
Natural-origin	407	5	60,526	1,381
SC steelhead				
Natural-origin	10	0	2,790	75
Green sturgeon	179	4	1,853	284
Eulachon	5,473	2,922	-	-

** Beginning with the 2012/2013 year class, hatchery origin CCC coho salmon are no longer adipose fin clipped (Ben White, pers. comm., August 25, 2015).*

Actual take levels associated with these activities are almost certain to be a good deal lower than the authorized levels. There are two reasons for this. First, most researchers do not handle or kill the full number of juveniles (or adults) they are allowed. Second, the estimates of mortality for each proposed study are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish—especially juveniles—would be killed during any given research project than the researchers are allotted, in some cases many fewer.

2.5 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. As noted earlier, we do not expect there to be any effects arising from activities that are interrelated or interdependent with the permit activities. Nor do we expect there the permit activities to have any negative indirect effects on listed species or their critical habitat.

2.5.1 Effects on Critical Habitat

Full descriptions of effects of the proposed research activities, as permitted, are found in the following section. In general, the permitted activities would be (1) electrofishing, (2) capturing fish with angling equipment, traps, and nets of various types, (3) collecting biological samples from live fish, and (4) collecting deceased fish for biological sampling. All of these techniques are minimally intrusive in terms of their effect on habitat because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. None of the activities will measurably affect any habitat PBF listed earlier. Moreover, the proposed activities are all of short duration. Therefore, we conclude that the proposed activities are not likely to have an adverse impact on any designated critical habitat.

2.5.2 Effects on Species

The primary effect of the proposed research will be on the listed species in the form of capturing and handling the fish. Capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, let alone entire species. The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the relevant permits. The activities would be carried out by trained professionals using established protocols. The effects of the activities have been well documented and are discussed in detail below. All permitted activities include compliance with the permit conditions described in Section 1.3 of this opinion as "Common Elements among the Proposed Permits."

Observing

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys or from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS' pre-established permit conditions (Section 1.3), would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

Capturing/Handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and wherever the fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 °F (18 °C) or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival of fish can result when stress levels are high because stress can be immediately debilitating and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly. The permit conditions contain measures that mitigate the factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover fairly rapidly from handling.

Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simply disturbing the fish to actually killing them. The amount of unintentional mortality attributable to electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician. Electrofishing can have severe effects on adult salmonids. Spinal injuries in adult salmonids from forced muscle contraction have been documented. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study.

Most of the studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 millimeters in length (Dalbey et al. 1996). The relatively few studies that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish are subjected to a lower voltage gradient than larger fish (Sharber and Carothers 1988) and may, therefore, be subject to lower injury rates (e.g., Hollender and Carline 1994, Dalbey et al. 1996, Thompson et al. 1997). McMichael et al. (1998) found a 5.1 percent injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin. The incidence and severity of electrofishing damage is partly related to the type of equipment used and the waveform produced (Sharber and Carothers 1988, McMichael 1993, Dalbey et al. 1996, Dwyer and White 1997). Continuous direct current (DC) or low-frequency (30 hertz) pulsed DC have been recommended for electrofishing (Fredenberg 1992, Snyder 1992, Dalbey et al. 1996) because lower spinal injury rates, particularly in salmonids, occur with these waveforms (Fredenberg 1992, McMichael 1993, Sharber et al. 1994, Dalbey et al. 1996). Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey et al. 1996, Ainslie et al. 1998). These studies indicate that although some of the fish suffer spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes they show no growth at all (Dalbey et al. 1996).

Permit conditions will require that all researchers follow NMFS' electrofishing guidelines (NMFS 2000), described in Section 1.3. The guidelines require that field crews be trained in observing animals for signs of stress and shown how to adjust electrofishing equipment to minimize that stress. All areas are visually searched for fish before electrofishing may begin. Electrofishing is not done in the vicinity of redds or spawning adults. All electrofishing equipment operators are trained by qualified personnel to be familiar with equipment handling, settings, maintenance, and safety. Operators work in pairs to increase both the number of fish that may be seen and the ability to identify individual fish without having to net them. Working in pairs also allows the researcher to net fish before they are subjected to higher electrical fields. Only DC units are used, and the equipment is regularly maintained to ensure proper operating condition. Voltage, pulse width, and rate are kept at minimal levels and water conductivity is tested at the start of every electrofishing session so those minimal levels can be determined. Due to the low settings used, shocked fish normally revive instantaneously. Fish requiring revivification receive immediate, adequate care. In all cases, electrofishing is used only when other survey methods are not feasible.

The preceding discussion focused on the effects of using a backpack unit for electrofishing and the ways those effects would be mitigated. In larger streams and rivers, electrofishing units are sometimes mounted on boats or rafts. These units often use more current than backpack electrofishing equipment because they need to cover larger (and deeper) areas and, as a result, can have a greater impact on fish. In addition, the environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. That is, in areas of lower visibility it can be difficult for researchers to detect the presence of adults and thereby take steps to avoid them. In any case, the permit conditions requiring the researchers to follow NMFS' electrofishing guidelines apply to researchers intending to use boat electrofishing as well. Furthermore, the permit conditions prohibit the researcher from intentionally targeting adult fish and the researcher must stop electrofishing if they encounter an adult fish.

Outmigrant Trapping

Smolt (and other down-migrating fish) traps – including rotary screw traps, fyke traps, and v-notch weir/pipe traps – are generally used to obtain information on natural population abundance and productivity. On average, they achieve a sample efficiency of four to 20 percent of the emigrating population from a river or stream – depending on river size. Although under some conditions traps may achieve a higher efficiency for a relatively short period of time (NMFS 2003). Based on years of sampling at hundreds of locations under hundreds of scientific research authorizations, we would expect the mortality rates for fish captured at rotary screw type traps to be one percent or less.

The trapping, capturing, or collecting and handling of juvenile fish using traps is likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 °F (18 °C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank.

The potential for unexpected injuries or mortalities among listed fish is reduced in a number of ways. These can be found in the individual study protocols and in the permit conditions stated earlier. In general, traps are checked at least daily and usually fish are handled in the morning. This ensures that the water temperature is at its daily minimum when fish are handled. Also, fish may not be handled if the water temperature exceeds 69.8 °F (21 °C). Great care must be taken when transferring fish from the trap to holding areas and the most benign methods available are used—often this means using sanctuary nets when transferring fish to holding containers to avoid potential injuries. The investigators' hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas. And often, several other stringent criteria are applied on a case-by case basis: safety protocols vary by river velocity and trap placement, the number of times the traps are checked varies by water and air temperatures, the number of people working at a given site varies by the number of outmigrants expected, etc. All of these protocols and more are used to make sure the mortality rates stay at one percent or lower.

Angling

Fish that are caught with hook and line and released alive may still die as a result of injuries or stress they experience during capture and handling. The likelihood of killing a fish varies widely, based on a number of factors including the gear type used, the species, the water conditions, and the care with which the fish is released.

The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality with barbless hooks and artificial bait is low. Nelson et al (2005) reported an average mortality of 3.6 percent for adult steelhead that were captured using barbless hooks and radio tagged in the Chilliwack River, BC. The authors also note that there was likely some tag loss and the actual mortality might be lower. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4 percent (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait, and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1 percent. Natural bait had slightly higher mortality (5.6 percent) than did artificial lures (3.8 percent), and barbed hooks (7.3 percent) had higher mortality than barbless hooks (2.9 percent). Hooton (1987) concluded that catching and releasing adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13 percent of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8 percent) of critical area hooking occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Data on summer-run steelhead and warmer water conditions are less abundant (Cramer et al. 1997). Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80 percent of the observed mortalities occurred at stream temperatures greater than 69.8 °F (21 °C). Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Hooton (1987) because of warmer water and that fact that summer fish have an extended freshwater residence that makes them more likely to be caught. As a result, NMFS expects steelhead hook and release mortality to be in the lower range discussed above.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of natural or synthetic bait reduces juvenile steelhead mortality more than any other angling regulatory change. Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992, Schill and Scarpella 1995, Mongillo 1984, Wydoski 1977, Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and White (1992) showed average mortality of trout to be 31.4 percent when using bait versus 4.9 and 3.8 percent for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32 percent) than mortality from actively fished bait (21 percent). Mortality of fish caught on artificial flies was only 3.9 percent. In the compendium of studies reviewed by Mongillo (1984), mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2 percent.

Most studies have found little difference (or inconclusive results) in the mortality of juvenile steelhead associated with using barbed versus barbless hooks, single versus treble hooks, and different hook sizes (Schill and Scarpella 1995; Taylor and White 1992; Mongillo 1984). However, some investigators believe that the use of barbless hooks reduces handling time and stress on hooked fish and adds to survival after release (Wydoski 1977). In summary, catch-and-release mortality of juvenile steelhead is generally less than 10 percent and approaches 0 percent when researchers are restricted to use of artificial flies and lures. As a result, all steelhead sampling via angling must be carried out using barbless artificial flies and lures.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook in Willamette River fisheries of 8.6 percent (Schroeder et al. 2000), which is similar to a mortality of 7.6 percent reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2 percent (Lindsay et al. 2004). In hooking mortality studies, hooking location and gear type is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8 percent in Lindsay et al. (2004) compared to fish hooked in the gills or esophagus (81.6 and 67.3 percent). A large portion of the mortality in the Lindsay et al. (2004) study was related to deep hooking by anglers using prawns or sand shrimp for bait on two-hook terminal tackle. Other baits and lures produced higher rates of jaw hooking than shrimp, and therefore produced lower hooking mortality estimates. The Alaska study reported very low incidence of deep hooking by anglers using lures and bait while fishing for salmon.

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee has adopted a 10 percent rate in order to make conservative estimates of unintentional mortality in fisheries (TAC 2008). Nonetheless, given the fact that no ESA section 10 permit or 4(d) authorization may "operate to the disadvantage of the species," we allow no more than a three percent mortality rate for any listed species collected via angling, and all such activities must employ barbless artificial lures and flies.

Weirs

Capture of adult salmonids by weirs is common practice in order to collect information; (1) enumerate adult salmon and steelhead entering the watershed; (2) determine the run timing of adult salmon and steelhead entering the watershed; (3) estimate the age, sex and length composition of the salmon escapement into the watershed; and (4) used to determine the genetic composition of fish passing through the weir (i.e. hatchery versus natural). Information pertaining to the run size, timing, age, sex and genetic composition of salmon and steelhead returning to the respective watershed will provide managers valuable information to refine existing management strategies.

Some weirs have a trap to capture fish, while other weirs have a video or DIDSON sonar to record fish migrating through the weir. Weirs with or without a trap, have the potential to delay migration. All weir projects will adhere to the draft NMFS West Coast Region Weir Guidelines and have included detailed descriptions of the weirs. The Weir Guidelines require the following: (1) traps must be checked and emptied daily, (2) all weirs including video and DIDSON sonar weirs must be inspected and cleaned of any debris daily, (3) the development and implementation of monitoring plans to assess passage delay, and (4) a development and implementation of a weir operating plan. These guidelines are intended to help improve fish weir design and operation in ways which will limit fish passage delays and increase weir efficiency.

Trawls

Trawls are cone-shaped, mesh nets that are towed, often, along benthic habitat (Hayes 1983, Hayes et al. 1996). Rectangular doors, attached to the towing cables, keep the mouth of the trawl open. Most trawls are towed behind a boat, but small trawls can be operated by hand. As fish enter the trawl, they tire and fall to the codend of the trawl. Mortality and injury rates associated with trawls can be high, particularly for small or fragile fish. Fish can be crushed by debris or other fish caught in the net. However, all of the trawling considered in this opinion is midwater trawling which may be less likely to capture heavy debris loads than benthic or demersal trawl sampling. Depending on mesh size, some small fish are able to escape the trawl through the netting. However, not all fish that escape the trawl are uninjured, as fish may be damaged while passing through the netting. Short duration trawl hauls (5 to 10 minutes maximum) may reduce injuries (Hayes 1983, Stickney 1983, Hayes et al. 1996).

Trammel Nets

Trammel nets are typically used by researchers to capture sturgeon. This netting technique, while potentially lethal for many species of fish, is somewhat safer for sturgeon. Both soak times and mesh size are important factors considered for safely capturing and handling sturgeon (Kahn and Mohead 2010). Mesh size that is too small for the targeted life stage is more likely to constrict gills resulting in mortality via suffocation. The mesh size chosen for trammel netting sturgeon, therefore, should be carefully considered and appropriate for the species and life stage targeted. Experimental nets with multiple mesh sizes may be appropriate for researchers to discover the safest and most effective mesh size (Kahn and Mohead 2010).

None of the permitted research projects will use 10 inch stretch mesh which has the highest mortality rate (Kahn and Mohead 2010), projects will use 4 square inch inner panel and 16 square inch outer panel trammel net. Effects of trammel nets are similair to gillnets, in that fish may have their gills impinged on the netting and may stress fish more than other passive gear types (Kahn and Mohead 2010). Trammel nets will not be soaked for more than one hour and will be manned at all times so that they can be checked as soon as fish entanglement is observed, and will not be fished in water temperature exceeding 69.8 °F (21 °C).

Benthic D-Nets

When targeting eggs and early life stage (ELS) sturgeon, two commonly used sampling methods are D-nets and artificial substrates (described below). Both techniques can be non-lethal, but due to the risk of mortality, no more eggs and ELS sturgeon should be captured than are absolutely necessary, as is the case for all sampling methods used to take listed species. In rivers with unknown spawning runs, adults can be tagged (described below) and tracked to document possible spawning runs and spawning areas prior to sampling for eggs (Kieffer and Kynard 1996). Otherwise, D-nets should be deployed well before the earliest time spawning would be expected. Due to the risks associated with capturing and impinging ELS sturgeon in the D-Nets, they should be checked at least every three hours to minimize unintentional mortality (Kahn and Mohead 2010).

Green sturgeon caught in Benthic D-nets are usually unharmed, however there is a risk associated with capturing and impinging ELS sturgeon in D-nets. The D-nets will be set for 10, 20, 30, or 60 minute increments depending on debris accumulation, fish occurrence, and mortality (Poytress et al. 2010). Based on these measures, NMFS expects mortalities to be low, or non-existant.

Egg Mats

Egg Mats are artifical substrates which consist of floor buffing pads, furnace filters, or similar materials, approximately two feet (0.61 meters) in diameter (described in Fox et al. 2000) for the purpose of collecting eggs as they are deposited in the water column. These pads should be anchored to the river bottom in suspected spawning areas. If the researcher is unsure of the number of pads required to identify spawning areas and success, no more than 100 to 150 pads should be fished at once across several sites (Kahn and Mohead 2010). Pads should be checked at least twice a week or more frequently if circumstances allow. The artificial substrates should be examined in the field for sturgeon eggs and the mat can be returned to the river bottom allowing the eggs to incubate and hatch before being removed (Kahn and Mohead 2010).

Egg Mats that would be used are constructed using two 35 x 24 inch (89 x 61 centimeter) rectangular sections of furnace filter material secured back to back within a welded steel framwork (McCabe and Beckman 1990, Schaffter 1997). The orientation of the furnace filter material allows either side of the egg mat to collect eggs (Poytress et al. 2010). Egg mats will be held in position by a three-fluke cement-filled poly-vinyl chloride anchor attached to the upstream end of the egg mat using 0.37-inch (9.5 millimeter) diameter braided polypropylene rope. A labeled float is attached to the downstram end of each egg mat using 0.37-inch (9.5 millimeter) diameter braided polyproplyene rope (Poytress et al. 2010).

Sampling consists of visual inspection, generally twice a week, throughout the sample period. Paired egg mats are retrieved from the river after initial deployment, placed on the deck of a boat in a custom made egg mat carrier, and initially inspected on both sides by at least two of the crew members. After initial inspection, crew members will rinse the egg mat to remove debris and sediment and re-inspected. Rinse water and debris are filtered by a removable 3.2 millimeters mesh net placed within the egg mat carrier below each egg mat to capture any dislodged eggs. After the second inspection and mesh net inspection, egg mats are redeployed (Poytress et al. 2010).

Egg samples are counted and identified to species for each egg mat in the field. Eggs are measured, both maximum length and width, in the field using digital calipers (± 0.01 millimeters) (Poytress et al. 2010). All suspected green sturgeon and unidentified eggs are placed in vials of 95 percent ethyl alcohol for laboratory identification, species confirmation, and further analysis. Eggs are pooled, by species, into the same vial only when found on the same side of one egg mat. Suspected green sturgeon and unidentified eggs are sent to UC Davis for positive species confirmation, photography, measurement of egg diameter, and determination of developmental stage (Dettlaff et al. 1993, Poytress et al. 2010).

Gastric Lavage

Knowledge of the food and feeding habits of fish are important in the study of aquatic ecosystems. However, in the past, food habit studies required researchers to kill fish for stomach removal and examination. Consequently, several methods have been developed to remove stomach contents without injuring the fish. Most techniques use a rigid or semi-rigid tube to inject water into the stomach to flush out the contents.

Few assessments have been conducted regarding the mortality rates associated with nonlethal methods of examining fish stomach contents (Kamler and Pope 2001). However, Strange and Kennedy (1981) assessed the survival of salmonids subjected to stomach flushing and found no difference between stomach-flushed fish and control fish that were held for three to five days. In addition, when Light et al. (1983) flushed the stomachs of electrofished and anesthetized brook trout, survival was 100 percent for the entire observation period. In contrast, Meehan and Miller

(1978) determined the survival rate of electrofished, anesthetized, and stomach flushed wild and hatchery coho salmon over a 30-day period to be 87 percent and 84 percent respectively.

Tissue Sampling

Tissue sampling techniques such as fin-clipping are common to many scientific research efforts using listed species. All sampling, handling, and clipping procedures have an inherent potential to stress, injure, or even kill the fish. This section discusses tissue sampling processes and its associated risks.

Fin clipping is the process of removing part or all of one or more fins to obtain non-lethal tissue samples and alter a fish's appearance (and thus make it identifiable). When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, severing individual fin rays (Welch and Mills 1981), or removing single prominent fin rays (Kohlhorst 1979). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (e.g., Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be more susceptible and Coble (1967) suggested that fish shorter than 90 millimeters are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100 percent recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are clipped. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality, but other studies have been less conclusive.

Tagging/Marking

Techniques such as PIT tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

A PIT tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore any researchers engaged in such activities will follow the conditions listed previously in this opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice et al. 1987, Jenkins and Smith 1990, Prentice et al. 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 kilometers), Hockersmith et al. (2000) concluded that the performance of yearling chinook salmon was not adversely affected by gastrically or surgically implanted sham radio tags or PIT tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Conner et al. 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain in the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman et al. 1968, Bordner et al. 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon; however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987, Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

The other primary method for tagging fish is to implant them with acoustic tags, radio tags, or archival loggers. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when adult salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting tags is to place them in the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed in the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985, Mellas and Haynes 1985).

Fish with internal tags often die at higher rates than fish tagged by other means because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982, Matthews and Reavis 1990, Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. As with the other forms of tagging and marking, researchers will keep the harm caused by tagging to a minimum by following the conditions in the permits as well as any other permit-specific requirements.

2.5.3 Species-specific Effects of Each Permit

In the "Status of the Species" section, we estimated the average annual abundance for adult and juvenile listed salmonids. For most of the listed species, we estimated abundance for adult returning fish and outmigrating smolts. For hatchery propagated juvenile salmonids, we use hatchery production goals. Life stage specific abundance estimates are not available for SC steelhead, but authorized take of SC steelhead resulting from research activities is discussed below within the context of the limited SC steelhead abundance information included in the "Status of the Species" section above. For sDPS green sturgeon and sDPS eulachon, estimates are available for spawners only. Table 29 displays the estimated annual abundance of hatchery-propagated and naturally produced listed fish.

Table 29. Summary of Estimated Annual Abundance of Listed Species.

Species	Life Stage	Origin/Production		
		Natural	Listed Hatchery Intact Adipose*	Listed Hatchery Adipose Clip*
CVSR Chinook	Adult	11,468	8,213	

Species	Life Stage	Natural	Origin/Production: Listed Hatchery Intact Adipose*	Origin/Production: Listed Hatchery Adipose Clip*
	Juvenile	2,386,000		2,878,601
SRWR Chinook	Adult	2,106	215	
	Juvenile	161,840		193,900
CC Chinook	Adult	7,034		
	Juvenile	1,278,078		
SONCC Coho	Adult	9,056	10,934	
	Juvenile	1,101,382	575,000	200,000
CCC Coho	Adult	1,621		
	Juvenile	90,000		250,000
CCV Steelhead	Adult	1,686	3,856	
	Juvenile	630,403		1,600,653
NC Steelhead	Adult	7,221		
	Juvenile	821,389		
CCC Steelhead	Adult	2,187	3,866	
	Juvenile	248,771		648,891
S-CCC Steelhead	Adult	695		
	Juvenile	79,057		
SC Steelhead	-	See Discussion		
Green Sturgeon	Adult	1,348		
Eulachon	Adult	81,736,000		

* We do not have separate estimates for adult adipose fin-clipped and intact adipose fin hatchery fish.

We evaluate the effects of proposed scientific research at the spatial scale or scales that are most relevant to the proposed action, i.e., at population- to ESU scales. For the proposed permits that we consider in this opinion, effects could occur broadly across the majority of the entire ESU/DPSs, and so we analyzed effects at the ESU/DPS scale. We evaluated proposed levels of total take and potential mortalities for each project. We then quantified how each permit's potential take would affect abundance and productivity at the ESU/DPS by life stage (juvenile, adult) and origin (natural, LHAC, LHIA).

Permit 1606-2R

Under Permit 1606-2R, Zack Larson and Associates is seeking to renew a five-year research permit to annually take juvenile SONCC coho in the Smith River, CA. Researchers may also take adult sDPS eulachon, for which there are currently no ESA take prohibitions. Fish would be captured with beach seines, fyke nets, electrofishing, minnow traps, and fence traps. Captured fish would be identified by species, enumerated, and released. The researchers do not propose to kill any fish.

The applicant is requesting the following amounts of take:

Table 30. Requested Take for Permit 1606-2R (C=Capture, H=Handle, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
SONCC coho	Juvenile	Natural	C/H/R	400	4
Eulachon	Adult	Natural	C/H/R	50	5

Because the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect less than a 1 percent unintentional mortality rate to be associated with the proposed capture methods at the local level and much less at the ESU/DPS level. The researchers would kill up to four juveniles SONCC coho juveniles and five adult eulachon (Table 30). We do not have population data for the Smith River. Therefore, we have analyzed the effects at the ESU/DPS scale.

This signifies that the researchers would kill, at most, the following percentages of listed fish:

Table 31. Percentage of the Estimated Annual Abundance, by ESU/DPS and Origin, Likely to be Killed by Permit 1606-2R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
SONCC coho	Juvenile	Natural	0.0003
Eulachon	Adult	Natural	<0.0001

Research associated with Permit 1606-2R would have a minimal impact on abundance—and therefore productivity—and no measurable effect on spatial structure or diversity for these listed species. The study would benefit listed fish by providing baseline and status data to aid in future recovery actions.

Permit 15573-3R

Under permit 15773-3R, Glenn-Colusa Irrigation District (GCID) is seeking to renew a five-year research permit to annually take juvenile CVSR and SRWR Chinook, CCV steelhead, and sDPS green sturgeon. Sampling would be conducted at an oxbow area off the mainstem Sacramento River. The GCID proposes to capture fish using rotatory screw traps. Captured fish would be identified by species, enumerated, and released or anesthetized, tagged, tissue sampled, allowed to recover and released.

The GCID is requesting the following amounts of take:

Table 32. Requested Take Permit 15573-3R (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release)

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CVSR Chinook	Juvenile	Natural	C/H/T/TS/R	3,150	95
SRWR Chinook	Juvenile	Natural	C/H/T/TS/R	4,400	132
SRWR Chinook	Juvenile	LHAC	C/H/T/TS/R	1,500	45
CCV Steelhead	Juvenile	Natural	C/H/R	500	15
CCV Steelhead	Juvenile	LHAC	C/H/R	2000	60
Green sturgeon	Juvenile	Natural	C/H/R	50	1

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect at least 97 percent of the juvenile fish captured by rotary screw traps to survive. No adults would be killed. Because the research would capture fish from numerous tributaries in the Sacramento River and delta we do not expect the research to have a disproportionate effect on any one population. Therefore, we have analyzed the effects at the ESU/DPS scale. For natural-origin juveniles, less than 0.004 percent of the CVSR Chinook ESU, 0.08 percent of the SRWR Chinook, and 0.002 percent of the CCV steelhead DPS would be killed (Table 33). For hatchery-origin juveniles, less than 0.02 percent of the SRWR ESU and 0.009 percent of the CCV steelhead DPS would be killed. Only one juvenile green sturgeon would be killed (Table 33).

Table 33. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 15573-2R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CVSR Chinook	Juvenile	Natural	0.004
SRWR Chinook	Juvenile	Natural	0.08
SRWR Chinook	Juvenile	LHAC	0.02
CCV Steelhead	Juvenile	Natural	0.002
CCV Steelhead	Juvenile	LHAC	0.009
Green sturgeon	Juvenile	Natural	<0.0001

Research associated with Permit 15573-3R would have a minimal impact on abundance—and therefore productivity—and no measurable effect on spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing, long-term, year-round monitoring at the GCID site. This data is used for reference and to provide monitoring related to restoration actions and to detect annular and cyclic population changes. Due to the longevity and consistency of the data obtained from the GCID site, this project provides the most complete data set on the Sacramento River.

Permit 15730-2R

Under permit 15730-2R, the Salmon Protection and Watershed Network (SPAWN) is seeking to renew a five-year permit to take CC Chinook, CCC coho, and CCC steelhead in the Lagunitas watersheds in Marin County, CA. The researchers would capture juvenile fish using fyke nets. The researchers would take tissue samples from adult carcasses. Captured fish would be identified by species, enumerated, and released or anesthetized, tagged, tissue sampled, allowed to recover and released.

The SPAWN is requesting the following amounts of take:

Table 34. Requested Take for Permit 15730-2R (C=Capture, H=Handle, R=Release, O=Observe, TS=Tissue sample, T=Tag).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CC Chinook	Juvenile	Natural	C/H/R	100	3
CC Chinook	Adult	Natural	O/TS	10	-
CCC Steelhead	Juvenile	Natural	C/H/R	10,000	200
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	1,900	57
CCC Steelhead	Spawned Adult/ Carcass	Natural	O/TS	50	-
CCC Coho	Juvenile	Natural	C/H/R	7,000	170
CCC Coho	Juvenile	Natural	C/H/T/TS/R	1,900	57

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect 97 percent of the fish captured using fyke nets to survive. We do not have population-level estimates for CC Chinook or CCC steelhead so we have analyzed the effects at the ESU/DPS scale, Therefore, we have analyzed the effects at the ESU/DPS scale. For juvenile fish, less than 0.0002 percent of the CC Chinook ESU, 0.103 percent of the CCC steelhead DPS, and 0.252 percent of the CCC coho ESU would be killed (Table 35). No adults would be killed.

Table 35. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 15730-2R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CC Chinook	Juvenile	Natural	0.0002
CCC Steelhead	Juvenile	Natural	0.103
CCC Coho	Juvenile	Natural	0.252

Research associated with Permit 15730-2R would have a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species. Assessing changes in the viability of the California coastal salmon remains a challenge due to the scarcity of long-term datasets for most populations. Results from this study would benefit listed species by supporting an ongoing, long-term, monitoring program and providing much needed status and trend data for central California coastal salmon.

Permit 15824-2R

Under permit 15824-2R, the County of Santa Cruz would take juvenile CCC steelhead, S-CCC steelhead and CCC coho in San Lorenzo, Soquel, Aptos and Corralitos watersheds in California. Fish would be captured by beach seine, backpack electrofishing, and observed during dive surveys. Captured fish would be identified by species, enumerated, and released or anesthetized, tagged, tissue sampled, allowed to recover and released. The researchers do not propose to kill any listed fish.

The applicant is requesting the following amounts of take:

Table 36. Percentage of the Estimated Annual Abundance of Juveniles Likely to be Killed by Permit 15824-2R (C=Capture, H=Handle, R=Release, T=Tag, TS=tissue sample, O=Observe, H = Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CCC Steelhead	Juvenile	Natural	C/H/R	8,455	84
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	365	5
CCC Steelhead	Juvenile	Natural	O/H	200	-
S-CCC Steelhead	Juvenile	Natural	C/H/R	2,790	27
S-CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	10	1
CCC coho	Juvenile	Natural	C/H/R	2,250	23

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect at least 97 percent of the fish captured to survive. We do not population-level data for San Lorenzo, Soquel, Aptos and Corralitos watersheds. Therefore, we have analyzed the effects at the ESU/DPS scale. For natural-origin juvenile fish, less than 0.036 percent of CCC steelhead DPS, 0.035 percent of the S-CCC steelhead DPS, and 0.025 percent of the CCC coho ESU would be killed (Table 37). No adults would be killed.

Table 37. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 15824-2R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CCC Steelhead	Juvenile	Natural	0.036
S-CCC Steelhead	Juvenile	Natural	0.035
CCC Coho	Juvenile	Natural	0.025

Research associated with Permit 15573-3R would have a minimal impact on abundance—and therefore productivity—and no measurable effect on spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program that provides data on juvenile salmonids in Santa Cruz watersheds. Assessing changes in the viability of the California coastal salmon remains a challenge due to the scarcity of long-term datasets for most populations.

Permit 16110-2R

The Marin Municipal Water District is seeking to renew a five-year permit to take CCC coho, CCC steelhead, and CC Chinook in Marin County, California. Fish would be captured with rotary screw traps, and backpack electrofishing. Fish would also be observed during dive and spawning surveys. Captured fish would be identified by species, enumerated, and released or anesthetized, measured, weighed, tagged, tissue sampled, allowed to recover and released. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities.

The Marin Municipal Water District is requesting the following amounts of take:

Table 38. Requested Additional Take in the Modification Request for Permit 16110-2R (C=Capture, H=Handle, R=Release, T=Tag, TS=Tissue Sample, O=Observe, H=Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CC Chinook	Juvenile	Natural	C/H/R	6,000	180
CC Chinook	Juvenile	Natural	C/H/T/TS/R	2,000	60
CCC Steelhead	Juvenile	Natural	C/H/R	20,500	615
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	3,300	99
CCC Steelhead	Juvenile	Natural	O/H	7,500	-
CCC Steelhead	Adult	Natural	O/H	1,200	-
CCC Coho	Juvenile	Natural	C/H/R	14,000	420
CCC Coho	Juvenile	Natural	C/H/T/TS/R	3,250	98
CCC Coho	Juvenile	Natural	O/H	4,000	0

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CCC Coho	Adult	Natural	O/H	2,200	-

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect at least 97 percent of the fish captured will survive. Because the research would be spread out across various tributaries in Marin County, we do not expect the research to have a disproportionate effect on any one population. In addition, we do not have population-level abundance estimates for CC Chinook or CCC steelhead so we have analyzed the effects at the ESU/DPS scale Therefore, we have analyzed the effects at the ESU/DPS scale. For natural-origin juveniles, less than 0.019 percent CC Chinook ESU, 0.287 percent of the CCC steelhead DPS, and 0.575 percent of the CCC coho ESU would be killed (Table 39). No adults would be killed.

This signifies that the researchers would kill, at most, the following percentages of listed fish:

Table 39. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 16110-2R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CC Chinook	Juvenile	Natural	0.019
CCC Steelhead	Juvenile	Natural	0.287
CCC Coho	Juvenile	Natural	0.575

Research associated with Permit 16110-2R would have a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing, long-term, monitoring program that provides life-cycle data for coho, steelhead and chinook in Marin County.

Permit 16417-2R

Under permit 16417-2R, the Santa Clara Valley Water District is seeking to renew a five-year permit to take CCC steelhead in Santa Clara County, CA. Fish will be observed at weirs, fish ladders, and dams. Fish would be captured using backpack electrofishing. Captured fish would be identified by species, enumerated, and released or anesthetized, measured, weighed, tagged, tissue sampled, allowed to recover and released.

The Santa Clara Valley Water District is requesting the following amounts of take:

Table 40. Requested Additional Take in Permit 16417-2R (C=Capture, H=Handle, R=Release, T=Tag, TS=Tissue Sample, O=Observe, H=Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CCC Steelhead	Juvenile	Natural	C/H/R	805	25
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	800	24
CCC Steelhead	Adult	Natural	C/H/R	5	0
CCC Steelhead	Adult	Natural	O/H	600	-

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect at least 97 percent of the captured fish to survive. Because the research would be spread out across various tributaries throughout Santa Clara County, we do not expect the research to have a disproportionate effect on any one population. Even if we had determined that a population level analysis was warranted, we do not have population-level abundance estimates for these populations. Therefore, we have analyzed the effects at the ESU/DPS scale. For natural-origin juveniles, 0.027 percent of the CCC steelhead DPS would be killed. For natural-origin adults, 0.228 percent of the CCC steelhead DPS would be killed (Table 41).

Table 41. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by the Additional Take in the Modification Request for Permit 16417-2R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CCC Steelhead	Juvenile	Natural	0.019
CCC Steelhead	Adult	Natural	-

Research associated with Permit 16417-2R would have a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program that provides baseline data on *O. mykiss* abundance, survival rates and movement patterns.

Permit 16544

Under 16544, the CDFW is seeking a new five-year research permit to take juvenile and adult throughout the range of SC steelhead in Southern CA. Fish would be captured with hand nets, fyke nets, backpack electrofishing, beach seines, weirs, minnow traps and hook and line sampling. Fish would also be overserved during spawning ground surveys and dive surveys.

Captured fish would be identified by species, enumerated, and released or anesthetized, measured, weighed, tagged, tissue sampled, allowed to recover and released.

The CDFW are requesting to following amounts of take:

Table 42. Requested Take Permit 16544 (C=Capture, H=Handle, R=Release, T=Tag, TS=Tissue Sample, O=Observe, H=Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
SC Steelhead	Juvenile	Natural	C/H/R	3,300	60
SC Steelhead	Juvenile	Natural	C/H/T/TS/R	16,900	487
SC Steelhead	Juvenile	Natural	O/TS	700	-
SC Steelhead	Juvenile	Natural	O/H	47,000	-
SC Steelhead	Adult	Natural	C/H/R	3	1
SC Steelhead	Adult	Natural	C/H/T/TS/R	42	7
SC Steelhead	Spawned Adult/ Carcass	Natural	O/TS	305	-
SC Steelhead	Adult	Natural	O/H	50	-

As previously mentioned, estimates of juvenile and adult abundance of SC steelhead are not available. At the local level we do not expect anything above a 3 percent mortality rate and that rate would be attenuated over the range of the SC steelhead. The purpose of this project is to establish a monitoring program to evaluate population status, trends, spatial structure and life history diversity of southern CA steelhead. The research proposed in permit 16544 was identified as research necessary to establish population abundances in the Steelhead Recovery Plan (NMFS 2012) and the California Coastal Monitoring Plan (Adams et al. 2011).

Permit 17428-3R

Under permit 17428-3R, the USFWS is seeking to renew a five-year research permit to take CVSR Chinook, SCWR Chinook, and CCV steelhead in the American River, California. Fish would be captured by rotary screwtrap. Captured fish would be identified by species, enumerated, and released or anesthetized, measured, weighed, tagged, tissue sampled, allowed to recover and released. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities.

The USWFS is requesting the following amounts of take:

Table 43. Requested Take Permit 17428-3R (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release).).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CVSR Chinook	Juvenile	Natural	C/H/T/TS/R	75	2
CVSR Chinook	Juvenile	LHAC	C/H/T/TS/R	75	2
SRWR Chinook	Juvenile	Natural	C/H/T/TS/R	50	1
SRWR Chinook	Juvenile	LHAC	C/H/T/TS/R	50	1
CCV Steelhead	Juvenile	Natural	C/H/R	2,700	82
CCV Steelhead	Adult	Natural	C/H/R	8	1
CCV Steelhead	Spawned Adult/ Carcass	Natural	O/TS	15	-

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect 97 percent of the fish captured to survive. At the population level, the research would kill, at most, 0.05 percent of the abundance of juvenile naturally produced CCV steelhead in the American River. We do not have abundance estimates for CVSR or SRWR Chinook in the American River. For natural-origin juveniles, less than <0.0001 of the CVSR Chinook ESU, 0.0006 percent of the SRWR Chinook ESU, and 0.013 percent of the CCV steelhead DPS would be killed. One adult CCV steelhead would be killed. For hatchery-origin juveniles, <0.001 of the CVSR Chinook ESU and 0.0005 percent of the SRWR Chinook ESU would be killed (Table 44).

Table 44. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by the Additional Take in the Modification Request for Permit 17428-3R.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CVSR Chinook	Juvenile	Natural	<0.0001
CVSR Chinook	Juvenile	LHAC	<0.0001
SRWR Chinook	Juvenile	Natural	0.0006
SRWR Chinook	Juvenile	LHAC	0.0005
CCV Steelhead	Juvenile	Natural	0.013
CCV Steelhead	Adult	Natural	0.059

Research associated with Permit 17428-3R would have a negligible impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program that is helping to generate data that is being incorporated into the salmon life cycle models NMFS staff are developing.

Permit 20622

Confluence Environmental Company applied for a new, five-year permit to take CC Chinook, SONCC coho, NC steelhead, sDPS green sturgeon in Humboldt Bay, CA. Researchers may also take adult sDPS eulachon, for which there are currently no ESA take prohibitions. Fish would be captured with a fyke net. Captured fish would be enumerated, handled and released.

The applicant is requesting the following amounts of take:

Table 45. Requested Take Permit 20622 (C=Capture, H=Handle, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CC Chinook	Juvenile	Natural	C/H/R	20	0
SONCC coho	Juvenile	Natural	C/H/R	20	0
NC Steelhead	Juvenile	Natural	C/H/R	20	0
sDPS green sturgeon	Juvenile	Natural	C/H/R	20	0
sDPS Eulachon	Juvenile	Natural	C/H/R	20	0

The researchers do not anticipate killing any fish for this study, and all captured fish are expected to recover with no ill effects, therefore the research associated with Permit 20622 would have a negligible impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed providing research and cross-training on the environmental impacts of shellfish aquaculture by furthering the understanding of how fish and invertebrate communities are affected by the presence of cultch-on-longline oyster aquaculture.

Permit 20792

FISHBIO applied for a new, five-year permit to take CVSR Chinook, CCV steelhead and sDPS green sturgeon in the San Joaquin River and South Delta. Fish would be captured by boat electrofishing, and they would be observed during fish or stream surveys. Captured fish would be enumerated, handled and released. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities.

FISHBIO is requesting the following amounts of take:

Table 46. Requested Take Permit 20792 (C=Capture, H=Handle, R=Release, O/H = Observe/Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality

CVSR Chinook	Juvenile	Natural	C/H/R	25	1
CVSR Chinook	Juvenile	Natural	O/H	150	-
CVSR Chinook	Juvenile	LHAC	C/H/R	30	1
CVSR Chinook	Adult	Natural	C/H/R	15	0
CVSR Chinook	Adult	Natural	O/H	100	-
CVSR Chinook	Adult	LHAC	C/H/R	20	1
CCV Steelhead	Juvenile	Natural	C/H/R	5	1
CCV Steelhead	Juvenile	Natural	O/H	10	-
CCV Steelhead	Juvenile	LHAC	C/H/R	5	1
CCV Steelhead	Adult	Natural	C/H/R	3	0
CCV Steelhead	Adult	Natural	O/H	7	-
CCV Steelhead	Adult	LHAC	C/H/R	5	0
sDPS green sturgeon	Juvenile	Natural	C/H/R	1	0
sDPS green sturgeon	Adult	Natural	O/H	3	-

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species.

Because the research would be spread out across the San Joaquin River and its delta, we do not expect the research to have a disproportionate effect on any one population. Therefore, we have analyzed the effects at the ESU/DPS scale. This signifies that the researchers would kill, at most, the following percentages of listed fish:

Table 47. Percentage of the Estimated Annual Abundance of Juveniles, by ESU/DPS and Origin, Likely to be Killed by Permit 20792.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CVSR Chinook	Juvenile	Natural	<0.0001
CVSR Chinook	Juvenile	LHAC	<0.0001
CVSR Chinook	Adult	Natural	0.0002
CVSR Chinook	Adult	LHAC	<0.0001
CCV Steelhead	Juvenile	LHAC	<0.0001

Research associated with Permit 20792 would have a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species Results from this study would benefit listed species by providing an understanding about the spatial distribution of non-native resident fishes in the San Joaquin River and Delta, and to identify areas of relatively elevated predator abundance to inform an understanding of potential impacts on juvenile salmonids migrating through this region

Permit 21499

The CA Department of Water Resources (DWR) applied for a new, five-year permit to take CVSR Chinook, SRWR Chinook, CCV steelhead, and sDPS green sturgeon in the Lower Sacramento River. Fish would be captured by boat electrofishing. Captured fish would be enumerated, handled and released.

The DWR is requesting the following amounts of take:

Table 48. Requested Take Permit 21499 (C=Capture, H=Handle, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CVSR Chinook	Juvenile	Natural	C/H/R	10	4
CVSR Chinook	Juvenile	LHAC	C/H/R	10	4
SRWR Chinook	Juvenile	Natural	C/H/R	4	2
SRWR Chinook	Juvenile	LHAC	C/H/R	4	2
CCV Steelhead	Juvenile	Natural	C/H/R	4	2
CCV Steelhead	Juvenile	LHAC	C/H/R	4	2
sDPS green sturgeon	Juvenile	Natural	C/H/R	4	2

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect 97 percent of the captured fish to survive. Because the research would be spread out across the lower Sacramento River, we do not expect the research to have a disproportionate effect on any one population. Therefore, we have analyzed the effects at the ESU/DPS scale.

This signifies that the researchers would kill, at most, the following percentages of listed fish:

Table 49. Percentage of the Estimated Annual Abundance by ESU/DPS and Origin, Likely to be Killed by Permit 21499.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CVSR Chinook	Juvenile	Natural	<0.0001
CVSR Chinook	Juvenile	LHAC	0.0001
SRWR Chinook	Juvenile	Natural	0.0012
SRWR Chinook	Juvenile	LHAC	0.0010
CCV Steelhead	Juvenile	Natural	0.0003

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CCV Steelhead	Juvenile	LHAC	0.0001
sDPS green sturgeon	Juvenile	Natural	*

*Do not have a population estimate for this life stage

Research associated with 21499 would have a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species. Results from this study would benefit listed species by providing data about fish community composition between the treated and untreated areas for aquatic weed control in the northern Sacramento-San Joaquin Delta to inform future studies on non-native predators and their habitats.

Permit 21547

The CA Department of Fish and Wildlife (CDFW) applied for a new, five-year permit to take CC, CVSR, and SRWR Chinook, CCV, CCC, NC and SC steelhead, SONCC coho, and sDPS green sturgeon. Fish would be captured by boat and backpack electrofishing, and with kick nets. Captured fish would be enumerated, handled and released.

The CDFW is requesting the following amounts of take:

Table 50. Requested Take Permit 21547 (C=Capture, H=Handle, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality
CC Chinook	Juvenile	Natural	C/H/R	10	1
CVSR Chinook	Juvenile	Natural	C/H/R	10	0
SRWR Chinook	Juvenile	Natural	C/H/R	2	0
SRWR Chinook	Juvenile	LHAC	C/H/R	3	0
CCV Steelhead	Juvenile	Natural	C/H/R	52	1
CCC Steelhead	Juvenile	Natural	C/H/R	5	0
NC Steelhead	Juvenile	Natural	C/H/R	37	2
SC Steelhead	Juvenile	Natural	C/H/R	1	0
SONCC Coho	Juvenile	Natural	C/H/R	87	4
sDPS green sturgeon	Adult	Natural	C/H/R	5	0

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers estimated for each species. We expect at least 97 percent of the fish that are captured to survive. Because the research would be spread out across the species' entire ranges in California, we do not expect the research to have a disproportionate effect on any one population. Therefore, we have analyzed the effects at the ESU/DPS scale.

This signifies that the researchers would kill, at most, the following percentages of listed fish:

Table 51. Percentage of the Estimated Annual Abundance by ESU/DPS and Origin, Likely to be Killed by Permit 21547.

ESU/ Species	Life Stage	Origin	Percent (percent) Mortalities
CC Chinook	Juvenile	Natural	<0.0001
CVSR Chinook	Juvenile	Natural	<0.0001
CCV Steelhead	Juvenile	Natural	0.0002
NC Steelhead	Juvenile	Natural	0.0002
SONCC Coho	Juvenile	Natural	0.0004

Research associated with Permit 21547 would have a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species. Results from this study would benefit listed species by providing information about the most critical factors affecting stream quality, thus providing insights about possible approaches to protect the health of streams in the region.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Because the navigable waters occur in the action area, the vast majority of future actions in the region will undergo section 7 consultation with one or more of the Federal entities with regulatory jurisdiction over water quality, flood management, navigation, or hydroelectric generation. In almost all instances, proponents of future actions will need government funding or authorization to carry out a project that may affect salmonids or their habitat, and therefore the effects such a project may have on salmon and steelhead will be analyzed when the need arises.

In developing this biological opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed salmonids—primarily the final recovery plans and efforts laid out in the 2011 and 2016 status review updates (see Section 2.2.2). The result of those reviews was that salmon take—particularly associated with research, monitoring, and habitat restoration—is likely to continue to increase in the region for the foreseeable future.

However, as noted above, most actions falling in those categories would also have to undergo consultation (like that documented in this opinion) before they are allowed to proceed.

Non-Federal actions are likely to continue affecting listed species. The cumulative effects in the action area are difficult to analyze because of this opinion's large geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing regional economies of California. Whether these effects will increase or decrease is a matter of speculation; however, given the trends in the region, the adverse cumulative effects are likely to increase. The primary cumulative effects will arise from those water quality and quantity impacts that occur as human population growth and development shift patterns of water and land use, thereby creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, baseflows, and peak flows. But the specifics of these effects, too, are impossible to predict at this time. In addition, there are the aforementioned effects of climate change—many of those will arise from or be exacerbated by actions taking place in California and elsewhere that will not undergo ESA consultation.

One final thing to take into account when considering cumulative effects is the time period over which the activity would operate. The permits here would be good for five years and the effects on listed species abundance they generate would continue for four years after that, though they would decrease in each succeeding year. We are unaware of any major non-Federal activity that could affect listed salmonids and is certain to occur in the action area during that time frame.

2.7 Integration and Synthesis of Effect

The Integration and Synthesis section is the final step in our process for assessing the effect that implementing the proposed action would have on listed species and their critical habitat. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2). They are also made in consideration of the other research that has been authorized and that may affect the various listed species. The reasons we integrate the proposed take in the permits considered here with the take from other research authorizations are that they are similar in nature and we have good information on what the effects are, and thus it is possible to determine the overall effect of all research in the region on the species considered here. The following two tables therefore (a) combine the proposed take for all the permits considered in this opinion for all components of each species (Table 52), (b) add the take proposed by the researchers in this opinion to the take that has already been authorized in the region, and then compare those totals to the estimated annual abundance of each species under consideration (Table 53).

Table 52. Total Requested Take and Mortalities for All Permits in this Opinion and Percentages of the Listed Units by Life Stage and Origin.

Species	Life Stage	Origin	Proposed Take (# fish)	Percent of Abundance (%)	Proposed Mortality (# fish)	Percent of ESU/DPS Killed (%)
CVSR Chinook	Adult	Natural	5	0.04	-	-
		LHAC	5	0.06	-	-
	Juvenile	Natural	3,270	0.14	102	0.004
		LHAC	115	0.003	7	0.0002
SRWR Chinook	Adult	Natural	-	-	-	-
		LHAC	-	-	-	-
	Juvenile	Natural	4,456	2.75	135	0.08
		LHAC	1,557	0.81	48	0.02
CC Chinook	Adult	Natural	-	-	-	-
	Juvenile	Natural	8,130	0.64	244	0.02
CCC Coho	Adult	Natural	-	-	-	-
		LHIA	-	-	-	-
	Juvenile	Natural	28,400	31.55	768	0.85
		LHIA	-	-	-	-
SONCC Coho	Adult	Natural	-	-	-	-
	Juvenile	Natural	507	0.046	8	0.0007
		LHIA	-	-	-	-
CCV Steelhead	Adult	Natural	11	0.65	1	0.059
		LHAC	5	0.13	-	-
	Juvenile	Natural	3,441	0.56	101	0.016
		LHAC	2,024	0.13	63	0.004
CCC Steelhead	Adult	Natural	5	0.23	0	-
		LHAC	-	-	-	-
	Juvenile	Natural	46,130	18.54	1,109	0.45
		LHAC	-	-	-	-
NC Steelhead	Adult	Natural	-	-	-	-
	Juvenile	Natural	57	0.007	2	0.0002
S-CCC Steelhead	Adult	Natural	-	-	-	-
	Juvenile	Natural	2,800	3.54	28	0.035
SC Steelhead	Adult	Natural	45	*	8	*
	Juvenile	Natural	20,201	*	547	*
Sturgeon	Adult	Natural	26	1.92	-	-
	Juvenile	Natural	54	*	3	*
Eulachon	Adult	Natural	70	<0.000	5	<0.000

** Do not have estimate of abundance for this life stage*

The proposed research activities would cause very low rates of take and mortality for salmon, steelhead, eulachon or green sturgeon (Table 52). The vast majority of adult and juvenile fish that researchers capture and release would recover quickly with no long-term physiological, behavioral, nor reproductive effects. The proposed research projects may kill, in sum, as much as 0.85 percent of the fish from any component of any listed species.

For reasons given below and in the effects analysis, these figures are probably much lower in actuality, but before engaging in that discussion, it is necessary to add all the take considered in this opinion to the rest of the research take that has been authorized that may affect the listed species included in this opinion (Table 53).

Because the majority of the fish that researchers capture and release are expected to recover shortly after handling with no long-term ill effects, the most meaningful effect of the action we consider here is the potential number of dead fish from each species. This signifies that all the research authorized for the species considered here—in combination with the proposed activities in this opinion—would have the following impacts in terms of the fish that may be killed.

Table 53. Percentage of Abundance that may be Lost among the Listed Species for All Previously Authorized Research and the Permit Actions Analyzed in this Opinion.

Species	Life Stage	Origin	Proposed Take (# fish)	Percent of Abundance (%)	Proposed Mortality (# fish)	Percent ESU/DPS Killed (%)
CVSR Chinook	Adult	Natural	684	5.97	22	0.19
		LHAC	687	8.36	252	3.07
	Juvenile	Natural	868,547	36.4	16,842	0.71
		LHAC	17,143	0.60	2,913	0.10
SRWR Chinook	Adult	Natural	271	12.87	11	0
		LHAC	237	110.23	53	24.65
	Juvenile	Natural	181,185	111.95	5,199	3.21
		LHAC	17,200	8.87	1,565	0.81
CC Chinook	Adult	Natural	930	13.22	35	0.50
	Juvenile	Natural	297,194	23.25	3,684	0.29
CCC Coho	Adult	Natural	3,128	192.97	44	2.71
		LHIA	1,582	*	37	*
	Juvenile	Natural	247,936	275.48	4,883	5.42
		LHIA	103,551	41.42	2,316	0.93
SONCC Coho	Adult	Natural	1,458	16.35	25	0.3
		LHIA	1,520	*	16	*
		LHAC	599	19	11	0.2
	Juvenile	Natural	180,024	16.35	2,497	0.23
		LHIC	7,850	1	706	0.1
		LHAC	1,496	0.7	44	0.02
CCV Steelhead	Adult	Natural	3,207	190	88	5.2
		LHAC	2,192	57	100	2.6
	Juvenile	Natural	64,184	10	2,081	0.3

		LHAC	14,022	0.9	899	0.1
CCC Steelhead	Adult	Natural	2,353	108	41	1.9
		LHAC	-	-	-	-
	Juvenile	Natural	239,241	96	5,574	2.2
		LHIA	-	-	-	-
NC Steelhead	Adult	Natural	3,033	42	14	0.2
	Juvenile	Natural	267,132	33	4,331	0.5
S-CCC Steelhead	Adult	Natural	407	58	5	0.7
	Juvenile	Natural	63,326	80	1,409	1.8
SC Steelhead	Adult	Natural	75	*	8	*
	Juvenile	Natural	23,201	*	634	*
Sturgeon	Adult	Natural	223	11.6	5	0.3
	Juvenile	Natural	2,109	*	121	*
Eulachon	Adult	Natural	5,543	0.007	2,927	0.004

** Do not have estimate of abundance for this life stage*

As the table above illustrates, in *many* cases, the dead fish from all of the permits in this opinion and all the previously authorized research would amount to a less than a percent of each species' total abundance. However, in ten of the cases, the potential mortality included in this opinion and all previously authorized research could amount to a more substantial percentage. Therefore, we will review the potential mortality for each species by origin and life stage.

Central Valley Spring-run Chinook salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for CVSR Chinook salmon would range from 0 to 3 percent of estimated species abundance—depending on the origin and life stage (Table 53). The 3 percent potential mortality figure is for adult LHAC Clipped origin fish that have no take prohibitions because they are considered surplus to recovery needs, therefore, we do not expect the loss to have any genuine effect on the species' survival and recovery in the wild. The potential mortality for natural origin CVSR Chinook salmon would range from 0.19 to 0.71 percent of estimated species abundance—depending on life stage. Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. The potential mortality for natural origin CVSR Chinook salmon would range from zero percent for adult salmon (no adult take proposed) to 0.6 percent (102/16,842) of the juvenile natural origin CVSR Chinook salmon mortality allotted to all the permitted research in California would result from activities contemplated in this opinion. Nearly all of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table 47 and 48 above. For naturally produced CVSR Chinook, our research tracking system reveals that for the past ten years, researchers ended up taking 11 percent of the adults and 9 percent of the juveniles they requested. The actual mortality was only 0.3 percent for adults and 4 percent for juveniles of what was requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Sacramento River Winter-run Chinook salmon

When combined with scientific research and monitoring permits already approved the potential mortality for SRWR Chinook salmon would range from 0 to 24.7 percent of estimated species abundance—depending on the origin and life stage (Table 53). The 24.7 percent potential mortality figure is for adult Listed Hatchery Adipose Clipped (LHAC) origin fish. To date, no LAHC adult fish have been killed during research activities so this 24.7 percent represents a large overestimation of fish that might be killed. The potential mortality for natural origin SRWR Chinook salmon would range from 0 to 3.2 percent of estimated species abundance. Thus the projected total mortalities take for all research and monitoring activities represents a small portion of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. The potential mortality for natural origin SRWR Chinook salmon would range from zero percent for adult salmon (no adult take proposed) to 2.6 percent (135/5,199) for juvenile. Therefore, nearly all of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 3 percent of the naturally produced adult and 12 percent of the juveniles they requested and the actual mortality was only 8 percent of the adults and 5 percent of the juveniles requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

California Coastal Chinook salmon

When combined with scientific research and monitoring permits already approved (Table 53), the potential mortality for CC Chinook salmon would range from 0.29 percent to 0.5 percent of estimated species abundance—depending on the life stage. The activities contemplated in this opinion represent only fractions of those already small numbers. In fact, none of the adult CC Chinook salmon mortality and only 6 percent (224/3,684) of the juvenile CC Chinook salmon mortality, would result from activities contemplated in this opinion. Therefore, nearly all of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. For CC Chinook, our research tracking system reveals that for the past ten years, researchers ended up taking 32 percent of the adult and 40 percent of the juveniles requested and the actual mortality was only 22 percent for adults and 8 percent for the juveniles requested. This would mean that the actual effect is likely to be much lower than the numbers stated in the table above.

Central California Coast coho salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for CCC coho salmon would range from 0.9 to 5.4 percent of estimated species abundance—depending on the origin and life stage (Table 53). The activities contemplated in this opinion represent only fractions of those already small numbers. In fact, none (0/44) of the adult CCC coho salmon mortality, and 15 percent (768/4,883) of the juvenile CC Chinook salmon mortality, would result from activities contemplated in this opinion. Therefore, nearly all of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

The true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 5 percent of the adults and 10 percent of the juveniles they requested and the actual mortality was only 0.5 percent of the adults and 3 percent of the juveniles requested.

Southern Oregon/Northern California Coast coho salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for SONCC coho salmon would range from 0.02 to 0.3 percent of estimated species abundance—depending on the origin and life stage (Table 53). Thus the projected total lethal take for all research and monitoring activities represents only fractions of a percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. The potential mortality for natural origin SONCC coho salmon would range from zero percent for adult salmon (no adult take proposed) to 0.3 percent (8/2,497) percent for juveniles from activities contemplated in this opinion. Therefore, nearly all of the potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 34 percent of the adult and 20 percent of the juvenile naturally produced fish they requested and the actual mortality was only 1.5 percent for adults and 4 percent for juveniles requested.

California Central Valley steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for CCV steelhead would range from 0.1 to 5.2 percent of estimated species abundance—depending on the origin and life stage (Table 53). However, the activities contemplated in this opinion represent only fractions of the potential mortality analyzed. In fact, just 1.1 percent (1/88) of the adult natural origin CCV steelhead mortality, and 4.8 percent (101/2,081) of the juvenile natural origin CCV steelhead mortality, would result from activities contemplated in this opinion. Therefore, the great majority of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 8 percent of the adult and 2 percent of the juvenile naturally produced fish they requested and the actual mortality was only 0.4 percent for adults and 3 percent for juveniles requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Central California Coast steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for CCC steelhead would range from 1.9 to 2.2 percent of estimated species abundance—depending on the life stage (Table 53). The activities contemplated in this opinion represent only fractions of the potential mortality rates. In fact, 12 percent (5/41) of the adult natural origin CCC steelhead mortality, and 20 percent (1,129/5,574) of the juvenile natural origin CCC steelhead mortality, would result from activities contemplated in this opinion.

Therefore, a good deal of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 3 percent of the adult and 13 percent of the juvenile CCC steelhead they requested and the actual mortality was only 1 percent of requested for adults and only 3 percent of the requested for juveniles. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Northern California steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for NC steelhead would range from 0.2 to 0.5 percent of estimated species abundance—depending on the life stage (Table 53). Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. In fact, zero percent (0/14) of the adult natural origin NC steelhead mortality (no adult take proposed), and 0.04 percent (2/4,331) of the juvenile natural origin NC steelhead mortality, would result from activities contemplated in this opinion. Therefore, a good deal of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 21 percent of the adult and 29 percent of the juvenile NC steelhead they requested and the actual mortality was only 0.8 percent of requested for adults and only 7 percent of the requested for juveniles. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

South-Central California Coast steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for S-CCC steelhead would range from 0.7 to 1.8 percent of estimated species abundance—depending on the age class (Table 53). Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. In fact, zero percent of the adult natural origin S-CCC steelhead mortality, and 2 percent (28/1,409) of the juvenile natural origin S-CCC steelhead mortality, would result from activities contemplated in this opinion. Therefore, a good deal of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 24 percent of the adult and 9 percent of the juvenile S-CCC steelhead they requested and the actual mortality was 0 percent of requested for adults and only 4 percent of the requested for juveniles. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Southern California steelhead

As previously mentioned, estimates of juvenile and adult abundance of SC steelhead are not available. The take included in this biological opinion will provide the information necessary to conduct the analysis of effects on this ESU. The project lethal mortality would be eight adults and 547 juvenile SC-steelhead. Our research tracking system reveals that researchers report, on average, 28 percent of the total take and 15 percent of the mortalities that are authorized in their permits so we anticipated these numbers to be much lower.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 37 percent of the adult and 9 percent of the juvenile SC steelhead they requested and the actual mortality was 0 percent of requested for adults and only 1 percent of the requested for juveniles. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Summation for Salmonids

One further thing to note for the all the species above: all the discussed impacts are ascribed to the natural component of each listed unit, but in actuality the effects are in all cases very likely to be smaller than the displayed percentages. The reason for this is that when in doubt—in those instances where a non-clipped hatchery fish cannot be differentiated from a natural fish—we ask that researchers err to the side of caution and treat all fish with intact adipose fins as if they were natural fish.

Moving from the specific to the general, it is necessary to note that for *all* the species the actual take amounts would almost certainly be a great deal smaller than what has been (or may be) authorized—particularly for juvenile fish. There are three reasons for this. First, we develop conservative estimates of juvenile abundance (described in subsection 2.2 above). Second, to account for potential accidental deaths, the researchers request more take and more mortalities than they estimate would actually occur in a given year. To illustrate this, our research tracking system reveals that on average researchers end up taking about 37 percent of the fish they estimate when applying for a permit and killing about 15 percent of the numbers they estimate. In the current context, this would mean that for the juvenile take in Table 53, above, that *actual* mortality levels would probably be nearly an order of magnitude smaller than those displayed. Third, some of the fish that may be affected would be in the smolt stage, but others definitely would not be. These latter would simply be described as "juveniles," which means they may actually be subyearlings, parr, or even fry. Thus, fish grouped into the juvenile life stage represent the progeny of multiple spawning years—a much greater number of individuals (perhaps as much as an order of magnitude greater) than is represented by the smolt stage.

Therefore, we derived the already small percentages for juvenile mortalities by (a) conservatively (under)estimating the actual number of outmigrating smolts (b) conservatively (over)estimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class when it is certain that at least some of them won't be. Thus, it is highly likely that the actual numbers of juvenile salmonids the research would kill are a great deal smaller than the stated figures. But even if the worst-case scenario were to occur and all the fish that may be killed are killed in fact, the effects of even the entire program would still be very small, restricted to abundance and productivity reductions, and the new effects contemplated in this opinion (even in total) would add almost no increment to the effects already considered and analyzed multiple times. In fact, as a general matter, the juvenile take contemplated in this opinion would actually be a great deal less than the baseline overall.

Similarly, the take contemplated in this opinion for the adult components would unlikely have significant effect on the species viability. Even if the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small. Because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect steelhead and promote their recovery.

Southern Distinct Population Segment Green Sturgeon

When combined with scientific research and monitoring permits already approved, the potential mortality for adult sDPS green sturgeon would constitute 0.3 percent of the estimated spawning abundance (Table 53). Further as noted in Section 2.2 above, the spawning run estimate for sDPS green sturgeon is conservative in that it doesn't include fish from the entire known spawning range of the DPS, and also does not include the members of the population which do not return to spawn each year. Further, some of the sampling occurs in Bay-Delta locations that are outside of the Sacramento River, where the spawning run size population estimate included for this analysis is derived, so the mortality would possibly be absorbed by a larger segment of the population then just the annual Sacramento River spawning run. In addition, a large percentage of the take that is listed in previously authorized permits as adult green sturgeon take, which occurs in the San Francisco Estuary, may be more aptly categorized as sub-adult or juvenile take. The annual abundance of juvenile green sturgeon is currently unknown due to a lack of knowledge of the survival rate of early life history stages of sDPS green sturgeon. However, given an annual spawning run estimate of 292 individuals, and a mean sDPS green sturgeon fecundity of 142,000 (Van Eenennaam et al. 2006), it can be safely assumed that 121 juvenile mortalities, even if those mortalities were sub adults, would represent a small fraction of the annual abundance of that life stage for the DPS. Further, for the juvenile component, just 2.5 percent (3/121) of the sDPS green sturgeon mortality would result from activities contemplated in this opinion. Therefore, most of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. The researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 9 percent of the sDPS they requested and the actual mortality was only 8 percent of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over portions of the species' range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect listed fishes and promote their recovery.

Southern Distinct Population Segment Eulachon

When combined with scientific research and monitoring permits already approved, the potential mortality for sDPS eulachon is 0.004 percent (Table 53). Thus the projected total mortality rate for all research and monitoring activities represents a small percent of the species' total abundance. In fact, 0.17 percent 5/2,927of the adult sDPS eulachon mortality would result from activities contemplated in this opinion. Therefore, a good deal of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over portions of the species' range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect listed fishes and promote their recovery.

Critical Habitat

As noted earlier, we do not expect the individual actions to have any appreciable effect on any listed species' critical habitat. This is true for all the proposed permit actions in combination as well: the actions' short durations, minimal intrusion, and overall lack of measureable effect signify that even when taken together they would have no discernible impact on critical habitat.

Summary

No listed species currently has all of its biological requirements met, as we discussed in Section 2.2. For these species to recover, there must be substantial improvement in habitat and other factors affecting survival. While the proposed research activities would have some negative effect on abundance and productivity for the species considered here, these effects are so small as to be minor. Research activities have never been identified as a threat to listed fish in the West Coast. We therefore conclude that the proposed research activities, individually and collectively, do not threaten the listed species.

While specific future cumulative effects are uncertain, cumulative effects will likely continue to be negative. The effects of climate change are also likely to continue to be negative. However, the very small effects from the proposed research activities on abundance and productivity, and even smaller effects on spatial structure and diversity, will not exacerbate any negative cumulative effects on the listed species.

The proposed research activities may benefit these species by providing information on status, trends, and ecological requirements. These data inform NMFS' 5-year status reviews for listed species and species recovery efforts. For example, juvenile fish trapping studies inform population inventories, tagging efforts increase our knowledge of fish migration timing and survival, and fish passage studies enhance our understanding of behavior and survival as fish migrate past dams and through reservoirs. The resulting information improves our understanding of these species' life histories, biological requirements, genetics, migration timing, responses to human activities, and freshwater and marine survival. By issuing research authorizations, NMFS facilitates science-based management of fisheries resources. Furthermore, the effects of the research on listed species, to some degree, would be offset by the information to be gained—information that in most cases would be directly used to protect listed species or promote their recovery.

Additionally, the information being generated is, to some extent, legally mandated. Though no law mandates the specific work being done in the proposed research actions, the ESA (section 4(c)(2)) requires that we examine the status of each listed species every five years and report on our findings. At that point, we must determine whether each listed species should (a) be removed from the list (b) have its status changed from threatened to endangered, or (c) have its status changed from endangered to threatened. Thus it is legally incumbent upon us to monitor the status of every species considered here—and the research program, as a whole, is one of the main means we have of doing that.

We expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult abundance and productivity. And because these reductions are so slight, the actions—even in combination—would have minimal effects on the species' diversity or structure. Moreover, we expect the actions to provide lasting benefits for the listed fish and that all habitat effects would be negligible. And finally, we expect the program as a whole and the permit actions considered here to generate information we need to fulfill our mandate under the ESA.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CVSR Chinook salmon, SRWR Chinook salmon, CC Chinook salmon, SONCC coho salmon, CCC coho salmon, CCV steelhead, NC steelhead, CCC steelhead, S-CCC steelhead, SC steelhead, sDPS green sturgeon, and sDPS eulachon or to destroy or adversely modify any designated critical habitat.

For reasons explained below (see the "Not Likely to Adversely Affect" Determinations section), the proposed action is Not Likely to Adversely Affect SR killer whales or their designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

In this instance, and for the actions considered in this opinion, there is no incidental take at all. The reason for this is that all the take contemplated in this document would be carried out under permits that allow the permit holders to *directly* take the animals in question. The actions are considered to be direct take rather than incidental take because in every case the permit holders' actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot be considered "incidental" under the definition give above. Nonetheless, one of the purposes of an incidental take statement is to lay out the amount or extent of take beyond which individuals carrying out an action cannot go without being in possible violation of section 9 of the ESA. That purpose is fulfilled here by the amounts of direct take laid out in the effects section above and reiterated in the integration and synthesis section. Those amounts—displayed in the various permits' effects analyses—constitute hard limits on both the amount and extent of take the permit holders would be allowed in a given year. This concept is also reflected in the second paragraph of the reinitiation clause just below.

2.10 Reinitiation of Consultation

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

As noted above, in the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. If any of the direct take amounts specified in this opinion's effects analysis section (2.4) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) and/or (3) will have been met.

2.11 "Not Likely to Adversely Affect" Determination

NMFS's determination that an action "is not likely to adversely affect" listed species or critical habitat is based on our finding that the effects are expected to be discountable, insignificant, or completely beneficial (USFWS and NMFS 1998). Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat.

Southern Resident Killer Whales Determination

The SR killer whale DPS composed of J, K, and L pods was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). The final rule listing SR killer whales as endangered identified several potential factors that may have caused their decline or may be limiting recovery. These factors include quantity and quality of prey, toxic chemicals which accumulate in top predators, and disturbance from sound and vessel traffic. The rule also identified oil spills as a potential risk factor for this species. The final recovery plan includes more information on these potential threats to SR killer whales (NMFS 2008).

NMFS published the final rule designating critical habitat for SR killer whales on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters including Puget Sound, but does not include areas with water less than 20 feet deep relative to extreme high water. The physical or biological features (PBFs) of SR killer whale critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

SR killer whales consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their preferred prey (review in NMFS 2008). Ongoing and past diet studies of SR killer whales conduct sampling primarily during spring, summer and fall months in inland waters of Washington State and British Columbia (i.e., Hanson et al. 2010a, Hanson et al 2010b; ongoing research by NWFSC). Therefore, our knowledge of diet preferences is specific to inland waters. Less is known about diet preferences of SR killer whales off the Pacific Coast. There are direct observations of two SR killer whale predation events in coastal waters, and in both the prey species was identified as Columbia River Chinook (Hanson et al. 2010b). Chemical analyses also support the importance of salmon in the year-round diet of SR killer whales (Krahn et al. 2002; Krahn et al. 2007). SR killer whales' preference for Chinook salmon in inland waters, even when other species are more abundant, combined with information indicating that the killer whales consume salmon year round, makes it reasonable to expect that SR killer whales likely prefer Chinook salmon when available in coastal waters.

The proposed permits covering the research activities evaluated in this opinion may affect SR killer whales indirectly by reducing availability of their primary prey, Chinook salmon. As described in the effects analysis for natural-origin salmonids, up to 102 juveniles and no adults from the CVSR Chinook, 135 juveniles and no adults from the SRWR Chinook and 244 juveniles and no adults from the CC Chinook ESUs may be killed during the proposed research. As the previous effects analysis illustrated, these losses—even in total—are expected to have only very small effects on salmonid abundance and productivity and no appreciable effect on diversity or distribution.

Nonetheless, the fact that the research would kill juvenile Chinook could affect prey availability to the SR killer whales in future years throughout their range in marine water along the West Coast. For the adult take, this is not an issue because no adult Chinook are expected to be killed and any that may unexpectedly die would have already left the SR killer whales range and would no longer be available as prey.

For the juveniles, the ten-year average smolt-to-adult ratio from CWT returns is no more than 0.5 percent for hatchery Chinook in the Columbia Basin (http://www.cbr.washington.edu/cwtSAR/). Average smolt-to-adult survival of naturally produced Chinook in the Columbia Basin is 1 percent (Schaller et al. 2007). Herein we assume a comparable rate for California populations. If one percent of the 536 juvenile Chinook salmon that may be killed by the proposed research activities were otherwise to survive to adulthood, this would translate to the effective loss of 5.4 adult Chinook salmon for a 5-year period after the research activities occurred (i.e., by the time these juveniles would have grown to be adults and available prey of killer whales). Given that the SRKW population must catch a minimum of 1,400 salmon daily to sustain their needs (Center for Whale Research 2018), this means that the research contemplated in this opinion could kill, in its entirety, 0.4 percent of *one day's* worth of the fish that the SRKW's need to survive. Moreover, that figure would only hold if the SRKWs could somehow intercept *all* the fish that might otherwise have grown to maturity. So even the maximum effect of a loss of 0.4 percent of one day's worth of SRKW food could only occur under the most extremely unlikely circumstances.

Given the total quantity of prey available to SR killer whales throughout their range, this reduction in prey is negligible (based on NMFS previous analysis of the effects of salmon harvest on SR killer whales; NMFS 2008). Therefore, the anticipated take of salmonids associated with the proposed scientific research permits would result in an insignificant reduction in adult equivalent prey resources for SR killer whales.

Future loss of Chinook salmon from Chinook salmon ESU populations could affect the prey PBF of designated critical habitat. As described above, however, considering the estimate of up to 4.8 adult equivalent Chinook salmon that could be taken by the proposed research activities, and the total amount of prey available in the critical habitat, the reduction would be insignificant and would not affect the conservation value of the critical habitat. Research activities associated with the proposed permits would have discountable effects on the water quality or passage PBFs for SR killer whales.

Therefore, we find that potential adverse effects of the proposed research on SR killer whales are discountable or insignificant and we determine that the proposed action may affect, but is not likely to adversely affect SR killer whales or their critical habitat.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based on the habitat effects analysis performed above and descriptions of EFH for Pacific coast salmon contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

In this instance, because no adverse effects on habitat are expected, no effects on EFH are anticipated either. As the biological opinion above states, the proposed research actions are not likely, singly or in combination, to adversely affect the habitat upon which Pacific salmon, groundfish, and coastal pelagic species, depend. All the actions are of limited duration, minimally intrusive, and are discountable in terms of their effects, short- or long-term, on any habitat parameter important to the fish.

The action agencies must reinitiate EFH consultation if plans for these actions are substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for the EFH conservation recommendations (50 CFR Section 600.920(k)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this consultation are the applicants and funding/action agencies listed on the first page. Individual copies were made available to the applicants. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, unbiased, and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this biological opinion/EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data, and analyses are properly referenced. They follow standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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5.1 Federal Register Notices

August 4, 1989 (54 FR 32085). Emergency Interim Rule: Endangered and Threatened Species; Critical Habitat; Winter-run Chinook Salmon.

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