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 Ten ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Eulachon and Green Sturgeon in Californian

NMFS Consultation Number: WCR-2017-7143
ARN: 151422WCR2017PR00169

Action Agencies: The National Marine Fisheries Service (NMFS)
Southwest Fisheries Science Center (SWFSC)
U.S. Fish and Wildlife Service (FWS)
U.S. Geological Survey (USGS)

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

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

ESA Section 7 Consultation Number WCR-2017-7143

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

Issued By:

FOR

Barry A. Thom
Regional Administrator

Date: September 28, 2017

TABLE OF CONTENTS

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 NMFS' review of ten proposed scientific research permit applications and is based on information provided in the 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 at Portland, OR.

1.2 Consultation History

The West Coast Region's Protected Resources Division (PRD) received ten applications for original permits and permit modifications and permit renewals (Table 1). 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). Four of the applications are for entirely new work and the other six are seeking permit modifications or renewals for permits that have previously been approved. As noted on the cover page, the affected species are California Coastal (CC) Chinook salmon, Central Valley spring-run (CVSR) Chinook salmon, Sacramento River winter-run (SRWR) 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.

The proposed actions also have the potential to affect Southern Resident (SR) killer whales and their critical habitat by diminishing the whales' prey base. We concluded that the proposed activities are not likely to adversely affect SR killer whales or their critical habitat and the full analysis is found in the "Not Likely to Adversely Affect" determination section (2.10).

Permit applications were submitted between July 18, 2015 and November 2, 2016. After coordinating with the applicants, all the updated applications were determined to be complete. A Notice of Receipt for all ten permit applications was published in the *Federal Register* asking for public comment on the applications—81 FR 94324 (December 23, 2016). 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 January 23, 2017, and no public comments were received so once the comment period closed, we initiated consultation on January 23, 2017. The full consultation histories for the ten 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 PRD in Portland, Oregon.

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

Permit Number	***Applicant***
Permit 19820	University of California in Davis, CA
Permit 17292	NMFS Southwest Fisheries Science Center (SWFSC)
Permit 20524	United States Geological Survey (USGS)
Permit 20035	Stillwater Sciences
Permit 17428-2M	United States Fish and Wildlife Service (USFWS)
Permit 17299-3M	NMFS Southwest Fisheries Science Center (SWFSC)
Permit 16531-2R	FISHBIO Environmental
Permit 15542-2R	Normandeau Associates
Permit 16318-2R	Hagar Environmental Services
Permit 10093-2R	California Department of Fish and Wildlife (CDFW)

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 permits to the ten applicants.

We are thus proposing to issue ten separate research permits pursuant to section 10(a)(1)(A) of the ESA. The permits would variously authorize researchers to take threatened CC Chinook salmon, threatened CVSR Chinook salmon, endangered SRWR Chinook salmon, threatened SONCC coho salmon, endangered CCC coho salmon, threatened CCV steelhead, threatened NC steelhead, threatened CCC steelhead, threatened S-CCC steelhead, endangered SC steelhead, and threatened sDPS green sturgeon. “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. 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.[1]

Permit 19820

Dr. James Hobbs, Professor at the University of California in Davis, CA is seeking a five-year research permit to annually take juvenile SRWR and CVSR Chinook, CCC and CCV steelhead, and sDPS green sturgeon in the San Francisco Bay Area and tributaries. The purpose of this research is to determine the degree to which Longfin Smelt use tributaries of San Pablo and San Francisco bays as spawning and rearing habitat. This information would improve the understanding of how bay tributaries contribute to the overall population of Longfin Smelt. Although this study principally targets Longfin Smelt, SRWR and CVSR Chinook, CCC and CCV steelhead and sDPS green sturgeon may be encountered during sampling. Fish would be captured with beach seines, fyke nets, and trawls (otter and Kodiak). Captured fish would be identified by species, enumerated, and released. A sub-sample of 30 individuals per species would be measured. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities. This research would enhance the knowledge of the distribution of the species in bay tributaries that have not been previously monitored.

Permit 17292

NMFS’s Southwest Fisheries Science Center (SWFSC) is seeking a five-year research permit to annually take adult and juvenile CC Chinook, CCC and SONCC coho, NC, S-CCC, SC and CCC steelhead. Sampling would be conducted in California on a variety of coastal salmonid populations. The purposes of this study are to: (1) estimate population abundance and dynamics; (2) evaluate factors affecting growth, survival, reproduction and life-history patterns; (3) assess life-stage specific habitat use and movement; (4) evaluate physiological performance and tolerance; (5) determine the genetic structure of populations; (6) evaluate the effects of water management and habitat restoration; and (7) develop improved sampling and monitoring methods. The SWFSC proposes to capture fish using backpack electrofishing, hook and line angling, hand and/or dipnets, beach seines, fyke nets, panel, pipe or screw traps, and weirs. The SWFSC also proposes to observe adult and juvenile salmonids during spawning ground surveys and snorkel surveys. Some of the fish the SWFSC captures would be anesthetized, measured, weighed, tagged (coded wire, elastomer, radio, acoustic, passive integrated transponder (PIT) or sonic), and tissue sampled for genetics identification. The SWFSC would also kill a portion of the fish for laboratory experiments on fish physiology and environmental tolerance, and as part of field-based research to assess performance, maternal origin (resident v. anadromous) and/or

[1] An ESU of Pacific salmon (Waples 1991) and a DPS of steelhead (71 FR 834) are considered to be “species” as the word is defined in section 3 of the ESA. In addition, we use the terms “artificially propagated” and “hatchery” interchangeably in the opinion (and the terms “naturally propagated” and “natural”).

life-history and habitat use (freshwater, estuarine and marine). The research would benefit the affected species by providing critical information in support of the conservation, management, and recovery of Coastal California salmon stocks.

Permit 20524

The United States Geological Survey (USGS) is seeking a five-year permit to take juvenile CC, SRWR and CVSR Chinook, CCC coho, CCC, CCV, S-CCC, SC steelhead, and sDPS green sturgeon. The goal of the California Stream Quality Assessment (CSQA) is to assess the quality of streams in California by characterizing multiple water-quality factors that are stressors to aquatic life and evaluating the relation between these stressors and biological communities. Approximately ninety sites would be sampled for up to nine weeks for contaminants, nutrients, and sediment in water. Stream-bed sediment would be collected during the ecological survey for analysis of sediment chemistry and toxicity. Fish would be collected via backpack electrofishing. Captured fish would be held in aerated live wells and buckets and would be identified, enumerated and released. A subset of non-listed fish from each site would be sacrificed for mercury analysis. The researchers do not propose to kill any listed fish but a small number may die as an unintended result of research activities. This research would benefit listed species by providing information about the most critical factors affecting stream quality and thus generate insights about possible approaches to protecting the health of streams in the region.

Permit 20035

Stillwater Sciences is seeking a one-year permit to take juvenile SONCC coho in the Salmon and Scott River floodplains (California). Fish would be captured by beach seine or minnow traps. The study is part of a larger comprehensive planning effort that would lead to strategic restoration of floodplains and mine tailings in the Salmon and Scott rivers. The purpose of this research is to assess mercury contamination in fish and invertebrates. Non-listed fish would be collected and sacrificed for tissue testing of mercury contamination. The sampling has the potential to capture juvenile SONCC coho salmon. As part of this project, information would be collected on coho (e.g., locations where individuals were observed and/or captured, habitat conditions) because this information will help determine the presence and distribution of coho—especially in the Salmon River where there is a paucity of such data. The researchers do not propose to kill any listed fish but a small number may die as an unintended result of research activities. The project would benefit listed species by providing data on mercury contamination, data that will be used to direct restoration efforts.

Permit 17428-2M

The U.S. Fish and Wildlife Service (FWS) is seeking to modify a 5-year permit that allows them to annually take juvenile CCV steelhead, juvenile SRWR and CVSR Chinook salmon, and juvenile sDPS green sturgeon at rotary screw traps in the American River in Sacramento County, California. The purposes of this study are to: (1) assess population-level abundance, production, condition, survival, and outmigration timing of juvenile salmonids; (2) evaluate the effectiveness of restoration actions; and (3) generate data that can be incorporated into life cycle models. Captured fish would be anesthetized, measured, weighed, tagged (acoustic or PIT), have a tissue sample taken, allowed to recover, and released. The modification is requested because the original permit application underestimated the number of CCV steelhead and SRWR and CVSR Chinook salmon that would be caught in the American River. The FWS is requesting a higher take limit and seeking to add green sturgeon because multiple years of trapping data suggest the authorized take limit needs to be adjusted. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. 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 project would benefit listed species by providing data that will be used to infer biological responses to ongoing habitat restoration activities, and direct future management activities to enhance the abundance, production, and survival of juvenile salmon and steelhead in the American River.

Permit 17299-3M

The SWFSC is seeking to modify a five-year permit that currently allows them to annually take juvenile CCV steelhead, juvenile SRWR and CVSR Chinook salmon. The sampling would take place in the Sacramento River and its tributaries. The purpose of this study is to document the survival, movement, habitat use and physiological capacity of Chinook salmon and steelhead and their predators in the Sacramento River basin. The SWFSC proposes to capture fish using hand and/or dipnets, beach seines, hook and line angling, and both backpack and boat-operated electrofishing. Captured fish would be anesthetized, tagged (sonic, acoustic, or PIT) and released. A subsample would have tissue samples taken. The SWFSC proposes to intentionally kill 50 natural CVSR juvenile chinook. From these, the researchers would collect otoliths for age/growth analysis, organ tissue for isotope, biochemical, and genomic expression assays and parasite infections. They would also collect stomach contents for diet analysis and tag effects/retention studies. Any CVSR fish that are unintentionally killed would be used in place of the intentional mortalities.

The permit would be modified to include (1) boat electroshocking, (2) PIT-tagging at screw trap locations in lieu of and/or in addition to acoustic tagging, (3) tissue and otolith sampling, and (4) the intentional directed mortality discussed above. The research would benefit the affected species by providing information to support the conservation, restoration, and management of Central Valley salmon stocks.

Permit 16531-2R

FISHBIO Environmental is seeking to renew a five-year research permit to take juvenile and adult CCV steelhead and CVSR Chinook in the Merced River (California). The purpose of this study is to obtain data on the habitat needs of fall-run Chinook and to assess the status of steelhead/rainbow trout in the Merced River. FISHBIO would capture fish with rotary screw traps and passively observe fish with a resistance board weir (equipped with an infrared camera) and during snorkel surveys. Fish captured at the screw traps would be anesthetized, identified by species, measured, weighed and released. A sub-sample of juvenile fall-run Chinook would be marked with a photonic dye to determine trap efficiency. Scale samples would be collected from up to 50 juvenile fall-run Chinook each week and from a small number of juvenile and adult *O. mykiss* during the season. Although fall-run Chinook are the researchers' primary target, they would also collect data rainbow trout/steelhead. The researchers do not propose to kill any fish, but a small number may die as an unintentional result of research activities. This research would benefit listed salmon by identifying factors that limit fish production in the Merced River.

Permit 15542-2R

Normandeau Associates is seeking to renew a five-year research permit to take juvenile and adult CCV steelhead in Lower Putah Creek in the lower Sacramento Basin (California). The purpose of this study is to monitor the distribution and relative abundance of fish populations in lower Putah Creek downstream of the Putah Diversion Dam. Fish would be captured by backpack and boat electrofishing. Captured fish would be identified by species, measured, weighed, 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. This research would benefit listed steelhead by providing information on fish response to river flows and on the distribution and diversity of rainbow trout/steelhead in Putah Creek.

Permit 16318-2R

Hagar Environmental Services is seeking to renew a five-year research permit to take juvenile CCC coho, CCC and S-CCC steelhead in the San Lorenzo-Soquel and Salinas subbasins. The purpose of this study is to assess salmonid habitat, presence, and abundance in order to inform watershed management and establish baseline population abundances before habitat conservation measures are implemented. The researchers would use backpack electrofishing and beach seines to capture the fish and would observe them during snorkel surveys. Captured fish would be enumerated, measured, and examined. Scale samples would be taken from a limited subset of individuals. Some salmonids would be PIT-tagged for a mark-recapture abundance estimation and to assess movement patterns. Snorkel surveys would be used in place of capture whenever possible. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities. This research would benefit listed species by providing population, distribution and habitat data that will be used to draft a Habitat Conservation Plan for the City of Santa Cruz.

Permit 10093-2R

The California Department of Fish and Wildlife (CDFW) is seeking to renew a five-year permit to take adult and juvenile CC Chinook, CCC and SONCC coho, and NC, S-CCC, SC and CCC steelhead. The project goal is to restore salmon and steelhead productivity in coastal California streams through a comprehensive restoration program. The specific goals of this research project are to assess fish abundance and distribution in coastal streams. Fish would be captured by backpack electrofishing, beach seine, minnow traps, and weirs, and they would be observed during snorkel and spawning ground surveys. Some fish would be anesthetized, measured, weighed, tagged, and tissue sampled for genetic information. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities. This research would benefit listed species by providing data to assess restoration projects and direct future habitat restoration needs.

Common Elements among the Proposed Actions

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 degrees Fahrenheit 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 degrees Fahrenheit.

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.nwr.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.

Finally, NMFS will use the annual reports to monitor the actual number of listed fish taken annually in the scientific research activities and will adjust annual 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.

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 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, 73 FR 7816). 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 DPSs.

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 sub adult 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 actions, 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 and steelhead—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)
- 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*	-
	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 CV spring-run 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 CV spring-run 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 6). 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 6. 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 (Ŝ) 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	Ŝ	N	10- year trend (95% CI)	Recent Decline (%)
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

Ŝ – 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 7), 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 7).

Table 7. 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
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). Data from http://www.calfish.org/LinkClick.aspx?fileticket=Kttf%2boZ2ras%3d&tabid=104&mid=524.
[c] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% 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 8. 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 9 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 9). 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 9. 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[ab]**
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
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% proportion of females*3,634 eggs per female*10% 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 10. 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
				P	Up. 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 11). 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 11. 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%. 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 12).

Table 12. 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 13) (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 13. 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% 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%. 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 habitat27: 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 14). 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 14. 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 15. 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% proportion of females*3,500 eggs per female*6.5% 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. Incidental 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 16 lists the historical NC steelhead independent populations, many of which are assumed to be extant (NMFS 2011a).

Table 16. 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 17). 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 17. 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 18).

Table 18. 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 (http://www.pottervalleywater.org/files/VAFS_fish_counts.csv), 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
	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 Mounta	**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% proportion of females*3,500 eggs per female*6.5% 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 21). 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 incidental 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% and 13% 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 19. 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 20). 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 20. 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

Diversity Strata	Populations
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 21). 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 21. Geometric Mean Abundances of CCC Steelhead Spawners Escapements by Population (Ettlinger et al. 2012, Jankovitz 2013, Source: http://marinwater.org/documents/1_WalkerCreekReportandRefs_March2010.pdf, Natural abundance: Manning and Martini-Lamb (ed.) 2012; Hatchery abundance source: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44269&inline=true, Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772, 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[ab]
	Austin Creek	2010-2012	63	-	7,166

Northern Coastal	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% proportion of females*3,500 eggs per female*6.5% 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 22). 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 22. 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 23. 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% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[b]Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&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/Fisheries%20Studies/AG_Steelhead_Report_Draft-small.pdf
[h]Source: http://www.coastalrcd.org/images/cms/files/MB%20Steelhead%20Abund%20and%20Dist%20Report.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 23). Juvenile S-CCC steelhead abundance estimates come from the escapement data (Table 23). 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[2] (Boughton et al. 2006). Very little data regarding abundances of 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

[2] Independent population: a collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations (Boughton et al. 2006).

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 24).

Table 24. 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	-
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).

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% 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% 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 25; NMFS 2015). There are no estimates for juvenile green sturgeon.

Table 25. Green sturgeon adult spawner numbers from DIDSON surveys in the upper Sacramento River and ESU estimate (NMFS 2015).

Year	Adult green sturgeon	95% 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.

2.2.3 Status of the Species' Critical Habitats

Due to the nature of the proposed activities the below section describes the status of critical habitat in the most general terms. That is, because the proposed actions 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[3]; 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 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).

[3] 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).

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.

2.3 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 research actions 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. 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 actions would take place in designated critical habitat.

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. As noted earlier, the proposed actions 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).

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 the majority 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 and highlighted in some species individual status section.

Table 26 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 29 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 26. 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). Table 27 below shows the total take NMFS has authorized for the ongoing research under the ESA sections 10(a)(1)(A) and 4(d).

Table 27. Total Section 10(a)(1)(A) and Section 4(d) Authorized Take of Salmon ESUs and Steelhead DPSs for Scientific Research and Monitoring in 2017.

DPS/ESU	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
CVSR Chinook salmon				
Natural-origin	3,463	77	864,070	16,688
Listed Hatchery Adipose Clip	28,232	472	16,140	2,817
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	957	32	537,853	5,632
SONCC coho salmon				
Natural-origin	1,499	23	175,538	2,368
Listed Hatchery Intact Adipose	1,520	16	7,850	706
Listed Hatchery Adipose Clip	593	9	1,634	169
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	3,396	85	59,749	1,905
Listed Hatchery Adipose Clip	2,030	94	12,010	824
NC steelhead				
Natural-origin	3,328	12	380,324	4,971
CCC steelhead				
Natural-origin	1,433	27	224,155	5,243
Listed Hatchery Adipose Clip	1,377	26	208,089	4,973
S-CCC steelhead				
Natural-origin	217	5	36,803	1,070

SC steelhead				
Natural-origin	10	0	2,790	75
Green sturgeon	179	4	1,853	284

** 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 (as discussed in Section 2.4.2 below). 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.

2.5.1 Effects on Critical Habitat

Full descriptions of effects of the proposed activities are found in the previous section. In general, the 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

As discussed above, the proposed research activities would have no measurable effects on listed salmonid or green sturgeon habitat. The actions are therefore not likely to jeopardize any of the listed salmonids or green sturgeon by reducing the ability of that habitat to contribute to their survival and recovery.

The primary effect of the proposed research will be on the listed species in the form of capturing and handling the fish. Harassment caused by 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. No researcher would receive a permit unless the activities (e.g., electrofishing) incorporate NMFS' uniform, pre-established set of mitigation measures—described in Section 1.3 of this opinion as "Common Elements among the Proposed Actions." These measures are incorporated (where relevant) into every research project as part of the conditions to which a researcher must adhere.

Observing/Harassing

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 mitigation measures (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 18º Celsius 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). 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° Fahrenheit (18° Celsius) 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° Fahrenheit (21° Celsius). 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% 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% (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%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). 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% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) 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 21° Celsius. 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% and approaches 0% 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 incidental 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, typically, 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 21° Celsius.

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 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 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 only returned to mat, 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 89 X 61 centimeters 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 9.5 millimeters diameter braided polypropylene rope. A labeled float is attached to the downstram end of each egg mat using 9.5 millimeters diamter 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 susceptible to it 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.

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 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.

Sacrifice

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if juveniles, are forever removed from the gene pool; if the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed from the population, but so are all their potential progeny. Thus, killing pre-spawning adults has the greatest potential to affect the listed species. Because of this, NMFS rarely allows it to happen. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults.

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. We estimated parr abundance for SONCC coho salmon. 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 28 displays the estimated annual abundance of hatchery-propagated and naturally produced listed fish.

Table 28. 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	
	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
SCCC Steelhead	Adult	695		
	Juvenile	79,057		
SC Steelhead	-	See Discussion		
Green Sturgeon	Adult	1,348		

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

In conducting the following analyses, we have tied the effects of each proposed action to its impacts on individual populations (or population groups) wherever it was possible to do so. In some instances, the nature of the project (i.e., it is broadly distributed or situated in mainstem habitat) was such that the take could not reliably be assigned to any population or group of populations. In those cases, the effects of the action are measured in terms of how they are expected to affect each species at the species scale, rather than at the population scale.

Permit 19820

Under Permit 19820, Dr. James Hobbs, Professor at the University of California in Davis, CA is seeking a five-year research permit to annually take juvenile SRWR and CVSR Chinook, CCC and CCV steelhead, and sDPS green sturgeon in the San Francisco Bay Area and tributaries. The purpose of this research is to determine the degree to which Longfin Smelt use tributaries of San Pablo and San Francisco bays as spawning and rearing habitat. This information would improve the understanding of how bay tributaries contribute to the overall population of Longfin Smelt. Although this study principally targets longfin smelt, SRWR and CVSR Chinook, CCC and CCV steelhead and sDPS green sturgeon may be encountered during sampling. Fish would be captured with beach seines, fyke nets, and trawls (otter and Kodiak). Captured fish would be identified by species, enumerated, and released. The researchers do not propose to kill any fish.

Dr. Hobbs is requesting the following amounts of take:

Table 29. Requested Take for Permit 19820 (C=Capture, H=Handle, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
CVSR Chinook	Juvenile	Natural	C/H/R	15	1
SRWR Chinook	Juvenile	Natural	C/H/R	3	0
CCV Steelhead	Juvenile	Natural	C/H/R	15	1
CCC Steelhead	Juvenile	Natural	C/H/R	15	1
Green Sturgeon	Subadult	Natural	C/H/R	3	0

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 expected for the species. This research may kill the following percentages of listed fish abundances (Table 30).

Table 30. Percentage of the Estimated Annual Abundance of Juveniles, by ESU/DPS and Origin, Likely to be Killed by Permit 19820.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CVSR Chinook	Juvenile	Natural	0.0000004%
SRWR Chinook	Juvenile	Natural	0%
CCV Steelhead	Juvenile	Natural	0.000002%
CCC Steelhead	Juvenile	Natural	0.000004%
Green Sturgeon	Subadult	Natural	0%

Because Dr. Hobbs research would be spread out across various tributaries of the San Pablo and San Francisco bays 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 abundance information for the tributaries of the bays. Therefore, we have analyzed the effects at the ESU/DPS scale. At the ESU/DPS level, the permitted activities may kill at most 0.000004% of the abundance of any ESU/DPS. Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. Though the purpose of the study is to monitor habitat use of Longfin Smelt, this research will also generate information on the location and distribution CVSR and SRWR Chinook and CCV and CCC steelhead in San Pablo Bay and South Bay. This information will benefit our understanding of status and trends monitoring, as well as planning for recovery actions.

Permit 17292

Under permit 17292, NMFS' Southwest Fisheries Science Center (SWFSC) is seeking a five-year research permit to annually take adult and juvenile CC Chinook, CCC and SONCC coho, NC, S-CCC, SC and CCC steelhead. Sampling would be conducted in California on a variety of coastal salmonid populations. The SWFSC proposes to capture fish using backpack electrofishing, hook and line angling, hand and dipnets, beach seines, fyke nets, panel, pipe or screw traps, and weirs. The SWFSC also proposes to observe adult and juvenile salmonids during spawning ground surveys and snorkel surveys. Some fish would anesthetized, measured, weighed, tagged (coded wire, elastomer, radio, acoustic, passive integrated transponder (PIT) or sonic), and tissue sampled for genetics identification. The SWFSC is also requesting intentional lethal take to support laboratory experiments using hatchery-origin fish whenever possible to examine fish physiology, environmental tolerance, and as part of field-based research to assess performance, maternal origin (resident v. anadromous) and/or life-history and habitat use (freshwater, estuarine and marine). Any fish unintentionally killed during the research would be used in lieu of a fish that would otherwise be sacrificed.

The SWFSC is requesting the following amounts of take:

Table 31. Requested Take Permit 17292 (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release, TR=transport, IDM = Intentional Directed Mortality, O/TS=Observe/Harass sample tissue dead animal, RWP=Removal from wild (permanent), IER=Import/export/receive only).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality	Intentional Directed Mortality
CC Chinook	Adult	Natural	C/H/T/TS/R	60	2	
CC Chinook	Juvenile	Natural	RWP	80	0	80
CCC Coho	Adult	LHIA	C/H/T/TS/R	1,325	27	
CCC Coho	Adult	LHIA	O/H	1,000	0	
CCC Coho	Adult	LHIA	O/TS	800	0	
CCC Coho	Adult	Natural	C/H/T/TS/R	425	8	
CCC Coho	Adult	Natural	O/H	800	0	
CCC Coho	Adult	Natural	O/TS	600	0	
CCC Coho	Juvenile	LHIA	C/H/R	8,000	160	
CCC Coho	Juvenile	LHIA	C/H/T/TS/R	19,600	392	
CCC Coho	Juvenile	LHIA	IER	900	0	900
CCC Coho	Juvenile	LHIA	IDM	80	0	80
CCC Coho	Juvenile	Natural	C/H/R	7,800	156	
CCC Coho	Juvenile	Natural	C/H/T/TS/R	15,800	316	
CCC Coho	Juvenile	Natural	RWP	80	0	80
CCC Coho	Juvenile	Natural	IDM	100	0	100
CCC Coho	Juvenile	Natural	O/H	8000	0	
SONCC Coho	Juvenile	LHIA	IDM	80	0	80
SONCC Coho	Juvenile	Natural	RWP	80	0	80
CCC Steelhead	Adult	LHAC	C/H/T/TS/R	475	10	
CCC Steelhead	Adult	LHAC	O/H	300	0	
CCC Steelhead	Adult	LHAC	O/TS	200	0	
CCC Steelhead	Adult	Natural	C/H/T/TS/R	1,025	10	
CCC Steelhead	Adult	Natural	O/H	1,000	0	
CCC Steelhead	Adult	Natural	O/TS	800	0	
CCC Steelhead	Juvenile	LHAC	C/H/R	7,000	140	
CCC Steelhead	Juvenile	LHAC	C/H/T/TS/R	2,500	50	
CCC Steelhead	Juvenile	LHAC	IER	500	0	500
CCC Steelhead	Juvenile	LHAC	IDM	80	0	80

CCC Steelhead	Juvenile	LHIA	C/H/R	3,000	60	
CCC Steelhead	Juvenile	LHIA	C/H/T/TS/R	3,200	64	
CCC Steelhead	Juvenile	Natural	C/H/R	14,300	286	
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	19,000	380	
CCC Steelhead	Juvenile	Natural	RWP	80	0	80
CCC Steelhead	Juvenile	Natural	IDM	125	0	80
CCC Steelhead	Juvenile	Natural	O/H	12,000	0	
NC Steelhead	Juvenile	Natural	RWP	80	0	80
S-CCC Steelhead	Juvenile	Natural	RWP	80	0	80

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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for these species (and their components) found in Table 28. Activities that would take fish that have already spawned or observe/harass juveniles and pre-spawn adults are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 32. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 17292.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CC Chinook	Juvenile	Natural	0.006
CC Chinook	Adult	Natural	0.03
CCC coho	Juvenile	LHIA	0.25
CCC coho	Juvenile	Natural	0.06
CCC coho	Adult	LHIA	-
CCC coho	Adult	Natural	0.12
SONCC coho	Juvenile	LHIA	0.01
SONCC coho	Juvenile	Natural	-
CCC steelhead	Juvenile	LHAC	0.04
CCC steelhead	Juvenile	LHIA	-
CCC steelhead	Juvenile	Natural	0.32
CCC steelhead	Adult	LHAC	0.26
CCC steelhead	Adult	Natural	0.46
NC steelhead	Juvenile	LHAC	-
S-CCC steelhead	Juvenile	Natural	-

This research will kill less than one percent of the adult CCC steelhead, and in all other cases, much less than one percent of the estimated abundance per ESU/DPS per life stage. The mortalities would be spread out over the whole of the ESU or DPS and therefore no population would be likely to be more affected than any other. Thus, even if all the authorized mortality did occur, there would only be very small impacts on the species' abundance and productivity, and no discernible effect on population structure or diversity. Further, those small losses would take place in the context of generating information to be used in species recovery; this research will provide critical information on the abundance and timing of listed fish coastal California watersheds.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the study is: (1) estimate population abundance and dynamics; (2) evaluate factors affecting growth, survival, reproduction and life-history patterns; (3) assess life-stage specific habitat use and movement; (4) evaluate physiological performance and tolerance; (5) determine the genetic structure of populations; (6) evaluate the effects of water management and habitat restoration; and (7) develop improved sampling and monitoring methods.. Specifically, the goals are to identify the life-history types present, their spatial and temporal distribution, their feeding ecology, and the interactions with other biota. The research would benefit the affected species by providing critical information in support of the conservation, management and recovery of Coastal California salmon stocks.

Permit 20524

Under permit 20524, The United States Geological Survey (USGS) is seeking a one-year permit to take juvenile CC, SRWR and CVSR Chinook, CCC coho, CCC, CCV, S-CCC, SC steelhead, and sDPS green sturgeon. The goal of the California Stream Quality Assessment (CSQA) is to assess the quality of streams in California by characterizing multiple water-quality factors that are stressors to aquatic life and evaluating the relation between these stressors and biological communities. Approximately ninety sites would be sampled for up to nine weeks for contaminants, nutrients, and sediment in water. Stream-bed sediment would be collected during the ecological survey for analysis of sediment chemistry and toxicity. Fish would be collected via backpack electrofishing. Captured fish would be held in aerated live wells and buckets and would be identified, enumerated and released. Any listed species encountered would be processed first and released immediately. A subset of non-listed fish from each site will be sacrificed for mercury analysis. The researchers do not propose to kill any listed fish but a small number may die as an unintended result of research activities. This research will 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.

Table 33. Requested Take for Permit 20524 (C=Capture, H=Handle, R=Release,).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
CVSR Chinook	Juvenile	Natural	C/H/R	613	15

SRWR Chinook	Juvenile	Natural	C/H/R	585	15
CC Chinook	Juvenile	Natural	C/H/R	755	20
CCC Coho	Juvenile	Natural	C/H/R	845	25
CCV Steelhead	Juvenile	Natural	C/H/R	1,534	40
CCC Steelhead	Juvenile	Natural	C/H/R	2,728	75
S-CCC Steelhead	Juvenile	Natural	C/H/R	729	20
SC Steelhead	Juvenile	Natural	C/H/R	210	5
Green sturgeon	Juvenile	Natural	C/H/R	400	10

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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for these species (and their components) found in Table 28.

Table 34. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 20524.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CVSR Chinook	Juvenile	Natural	0.001
SRWR Chinook	Juvenile	Natural	0.009
CC Chinook	Juvenile	Natural	0.002
CCC Coho	Juvenile	Natural	0.003
CCV Steelhead	Juvenile	Natural	0.006
CCC Steelhead	Juvenile	Natural	0.03
S-CCC Steelhead	Juvenile	Natural	0.025
SC Steelhead	Juvenile	Natural	*
SC Steelhead	Adult	Natural	0
Green sturgeon	Juvenile	Natural	0.7

Since take activities would occur throughout the state of California, the effect of that take cannot be examined at the population level. At the salmon ESU/steelhead DPS levels, the permitted activities may kill, at most, 0.03 percent of the estimated outmigration for any ESU/DPS by origin. We do not have an abundance estimate for the juvenile life-stage of green sturgeon. We therefore compared the proposed take to the abundance of adult sturgeon, an abundance estimate that is likely to be much smaller than the number of juveniles. For green sturgeon, the proposed research may kill, at most, 0.7% of the estimated abundance of the species.

Overall, the research take would have a very small impact on the abundance of any ESU/DPS of salmon, steelhead, or sturgeon, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Moreover, it is possible that the actual effect would be even smaller as the mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the study is to assess the quality of streams in California by characterizing multiple water-quality factors that are stressors to aquatic life and evaluating the relation between these stressors and biological communities. This research 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.

Permit 20035

Under permit 20035, Stillwater Sciences would take juvenile SONCC coho in the Salmon and Scott River floodplains (California). Fish would be captured by beach seine or minnow traps. The purpose of this research is to assess mercury contamination in fish and invertebrates. Non-listed fish would be collected and sacrificed for tissue testing of mercury contamination. The sampling has the potential to capture juvenile SONCC coho salmon. As part of this project, information would be collected on coho (e.g., locations where individuals were observed and/or captured, habitat conditions) because this information will help determine the presence and distribution of coho—especially in the Salmon River where there is a paucity of such data. The researchers do not propose to kill any listed fish. Any listed species encountered would be processed first and released immediately.

Table 35. Percentage of the Estimated Annual Abundance of Juveniles Likely to be Killed by Permit 20035.

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
SONCC coho	Juvenile	Natural	C/H/R	10	1

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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants expected for SONCC coho.

The abundance estimate for adult coho returning to the Scott River is 357 (Table 11). 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 178 females returning (half of the average total number of spawners), approximately 512,284 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%. Thus, we can state that the Scott River could produce roughly 35,860 juvenile natural SONCC coho salmon each year. Comparing the unintentional mortality of one juvenile naturally produced coho to the estimated abundance (1/35,860) the research may have a minimal effect (0.003%) on abundance in the Scott River. Overall, the research take would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Moreover, it is possible that the actual effect would be even smaller as the juvenile mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this research is to assess mercury contamination in fish and invertebrates. This research would benefit listed species by providing data on mercury contamination, data that will be used to direct restoration efforts.

Permit 17428-2M

The FWS is requesting to modify permit 17428-2M, a 5-year permit that allows them to annually take juvenile CCV steelhead, juvenile SRWR and CVSR Chinook salmon at rotary screw traps in the American River in Sacramento County, California. Captured fish would be anesthetized, measured, weighed, tagged (acoustic or PIT), have a tissue sample taken, allowed to recover, and released. The modification is requested because the original permit application underestimated the number of CCV steelhead and SRWR and CVSR Chinook salmon that would be caught in the American River. The FWS is requesting a higher take limit and seeking to add green sturgeon because multiple years of trapping data suggest the authorized take limit needs to be adjusted. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. 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 researchers are requesting to add the following amounts of take to their existing permit.

Table 36. Requested Additional Take in the Modification Request for Permit 17428-2M (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
CVSR Chinook	Juvenile	Natural	C/H/T/TS/R	30	-
CVSR Chinook	Juvenile	LHAC	C/H/T/TS/R	75	2

SRWR Chinook	Juvenile	Natural	C/H/T/TS/R	15	-
SRWR Chinook	Juvenile	LHAC	C/H/T/TS/R	50	1
CCV Steelhead	Juvenile	Natural	C/H/R	2,550	70
CCV Steelhead	Adult	Natural	C/H/R	3	-
CCV Steelhead	Spawned Adult/ Carcass	Natural	O/TS	7	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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for the population and the species (and their components) found in Table 28. Activities that would take spawned adult/carcass steelhead are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 37. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by the Additional Take Requested in the Modification for Permit 17428-2M.

ESU/ Species	Life Stage	Origin	Population Scale Percent (%) Mortalities	ESU/DPS Scale Percent (%) Mortalities
CVSR Chinook	Juvenile	Natural	*	0
CVSR Chinook	Juvenile	LHAC	*	0.00007
SRWR Chinook	Juvenile	Natural	*	0
SRWR Chinook	Juvenile	LHAC	*	0.0005
CCV Steelhead	Juvenile	Natural	0.05	0.01
CCV Steelhead	Adult	Natural	0	0

The research would kill, at most, 0.05% 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. At the ESU/DPS scale, the research would kill, at most, 0.01 percent of the estimated outmigration for any ESU/DPS by origin. Overall, the research would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Furthermore, the effects of the research is likely to be even smaller than what we analyzed as the juvenile mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purposes of this study are to: (1) assess population-level abundance, production, condition, survival, and outmigration timing of juvenile salmonids; (2) evaluate the effectiveness of restoration actions; and (3) generate data that can be incorporated into life cycle models. The project would benefit listed species by providing data that will be used to infer biological responses to ongoing habitat restoration activities, and direct future management activities to enhance the abundance, production, and survival of juvenile salmon and steelhead in the American River.

Permit 17299-3M

Under permit 17299-3M, the SWFSC would modify a five-year permit that currently allows them to annually take juvenile CCV steelhead, juvenile SRWR and CVSR Chinook salmon. Sampling would take place in the Sacramento River and its tributaries. Currently, the SWFSC captures fish using hand and/or dipnets, beach seines, hook and line angling, and backpack electrofishing. The permit would be modified to include (1) boat electroshocking, (2) PIT-tagging at screw trap locations in lieu of and/or in addition to acoustic tagging, (3) tissue and otolith sampling, and (4) the intentional directed mortality. In their modification request, the SWFSC proposes to intentionally kill 50 CVSR juvenile chinook to collect otoliths for age/growth analysis, organ tissue for isotope, biochemical, and genomic expression assays and parasite infections. They would also collect stomach contents for diet analysis and tag effects/retention studies. Any CVSR fish that are unintentionally killed would be used in place of the intentional mortalities.

The researchers are requesting to add the following amounts of take to their existing permit.

Table 38. Requested Additional Take in Permit 17299-3M (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release, IDM = Intentional Directed Mortality).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality	Intentional Directed Mortality
CVSR Chinook	Juvenile	Natural	C/H/R	100	3	-
CVSR Chinook	Juvenile	Natural	C/H/T/TS/R	400	-	-
CVSR Chinook	Juvenile	Natural	IDM	50	-	50
CVSR Chinook	Juvenile	LHAC	C/H/R	100	3	-
CVSR Chinook	Adult	Natural	C/H/R	10	-	-
CVSR Chinook	Adult	LHAC	C/H/R	10	-	-
SRWR Chinook	Juvenile	Natural	C/H/R	10	1	-

SRWR Chinook	Juvenile	LHAC	C/H/R	10	1	-
SRWR Chinook	Adult	Natural	C/H/R	10	-	-
SRWR Chinook	Adult	LHAC	C/H/R	10	-	-
CCV Steelhead	Juvenile	Natural	C/H/R	100	3	-
CCV Steelhead	Juvenile	LHAC	C/H/R	100	3	-
CCV Steelhead	Adult	Natural	C/H/R	10	-	-
CCV Steelhead	Adult	LHAC	C/H/R	10	1	
Green sturgeon	Juvenile	Natural	C/H/R	10	1	-
Green sturgeon	Adult	Natural	C/H/R	10	-	-

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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for these species (and their components) found in Table 28.

Table 39. 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 17299-3M.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CVSR Chinook	Juvenile	Natural	0.002
CVSR Chinook	Juvenile	LHAC	0.0001
CVSR Chinook	Adult	Natural	0
CVSR Chinook	Adult	LHAC	0
SRWR Chinook	Juvenile	Natural	0.0006
SRWR Chinook	Juvenile	LHAC	0.0005
SRWR Chinook	Adult	Natural	0
SRWR Chinook	Adult	LHAC	0
CCV Steelhead	Juvenile	Natural	0.0004
CCV Steelhead	Juvenile	LHAC	0.0002
CCV Steelhead	Adult	Natural	0
CCV Steelhead	Adult	LHAC	0.03

Green sturgeon	Juvenile	Natural	0.07
Green sturgeon	Adult	Natural	0

In their proposed modification, the SWFSC would would kill, at most, 0.03 percent of any hatchery origin salmonid species. The SWFSC would also kill, at most, 0.002 percent of any natural origin salmonid species. We do not have an abundance estimate for the juvenile life-stage of green sturgeon. We therefore compared the proposed take to the abundance of adult sturgeon, an abundance estimate that is likely to be much smaller than the number of juveniles. For green sturgeon, the SWFSC' proposed modification request may kill, at most, 0.07% of the estimated abundance of the species.

Overall, the research would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Furthermore, the effects of the research is likely to be even smaller than what we analyzed as the juvenile mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to document the survival, movement, habitat use and physiological capacity of Chinook salmon and steelhead and their predators in the Sacramento River basin. The research would benefit the affected species by providing information to support the conservation, restoration, and management of Central Valley salmon stocks.

Permit 16531-2R

Under 16531-2R, FISHBIO Environmental is seeking to renew a five-year research permit to take juvenile and adult CCV steelhead and CVSR Chinook in the Merced River (California). Fish would be captured at rotary screw traps and passively observed at a resistance board weir equipped with an infrared camera and during snorkel surveys. Fish captured at the screw traps would be anesthetized, identified by species, measured, weighed and released. A sub-sample of juvenile fall-run Chinook would be marked with a photonic dye to determine trap efficiency. Scale samples would be collected from up to 50 juvenile fall-run Chinook each week and from a small number of juvenile and adult *O. mykiss* during the season. Although fall-run Chinook are the researchers' primary target, they would also collect data rainbow trout/steelhead.

Table 40. Requested Take Permit 16531-2R (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release, O=Observe, H=Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
CVSR Chinook	Juvenile	Natural	C/H/R	40	2
CVSR	Juvenile	LHAC	C/H/R	40	2

Chinook					
CCV Steelhead	Juvenile	Natural	C/H/T/TS/R	5	1
CCV Steelhead	Juvenile	Natural	O/H	5,255	-
CCV Steelhead	Juvenile	LHAC	C/H/T/TS/R	5	1
CCV Steelhead	Juvenile	LHAC	O/H	5	-
CCV Steelhead	Adult	Natural	C/H/T/TS/R	1	-
CCV Steelhead	Adult	Natural	O/H	160	-
CCV Steelhead	Adult	LHAC	C/H/T/TS/R	1	-
CCV Steelhead	Adult	LHAC	O/H	5	-
CCV Steelhead	Spawned Adult/Carcass	Natural	O/TS	3	-
CCV Steelhead	Spawned Adult/Carcass	LHAC	O/TS	3	-

Because the 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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for these species (and their components) found in Table 40. Activities that would take spawned adult/carcass steelhead or observe/harass fish are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 41. Percentage of the Estimated Annual Abundance of Juveniles and Adults, by ESU/DPS and Origin, Likely to be Killed by Permit 16531-2R.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CVSR Chinook	Juvenile	Natural	0.00008
CVSR Chinook	Juvenile	LHAC	0.00007
CCV Steelhead	Juvenile	Natural	0.0002
CCV Steelhead	Juvenile	LHAC	0.00006
CCV Steelhead	Adult	Natural	0
CCV Steelhead	Adult	LHAC	0

We do not have abundance estimates for the number of Chinook and steelhead in the San Joaquin basin or its tributaries. We therefore compare the number of fish that may be killed by the research to the abundance of the ESU/DPS. At the salmon ESU/steelhead DPS levels, the permitted activities may kill, at most, 0.0002 percent of the estimated outmigration for any ESU/DPS by origin. Overall, the research would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Furthermore, the effects of the research is likely to be even smaller than what we analyzed as the juvenile mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to obtain data on the habitat needs of fall-run Chinook and to assess the status of steelhead/rainbow trout in the Merced River. This research would benefit listed salmon by identifying factors that limit fish production in the Merced River.

Permit 15542-2R

Under permit 15542-2R, Normandeau Associates is seeking to renew a five-year research permit to take juvenile and adult CCV steelhead in Lower Putah Creek in the lower Sacramento Basin (California). Fish would be captured by backpack and boat electrofishing. Captured fish would be identified by species, measured, weighed, 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.

Table 42. Requested Take Permit 15542-2R (C=Capture, H=Handle, R=Release).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
CCV Steelhead	Juvenile	Natural	C/H/R	250	8
CCV Steelhead	Juvenile	Adult	C/H/R	2	0

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. We do not have abundance estimates for the number of steelhead in Putah Creek. We therefore compare the number of fish that may be killed by the research to the abundance of the DPS. This project anticipates killing eight fish which represents less than 0.001 percent (8/630,403) of the estimated number of naturally produced CCV steelhead. Overall, the research would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. In addition to the very low level of effect, the majority of the fish encountered in Lower Putah Creek are likely to be resident rainbow trout, based on genetic studies and observation, so the effect is even less that described here. Furthermore, the effects of the research is likely to be even smaller than what we analyzed as the juvenile mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to monitor the distribution and relative abundance of fish populations in lower Putah Creek downstream of the Putah Diversion Dam. This research would benefit listed steelhead by providing information on fish response to river flows, and on distribution and diversity of rainbow trout/steelhead in Putah Creek.

Permit 16318-2R

Under permit 16318-2R, Hagar Environmental Services is seeking to renew a five-year research permit to take juvenile CCC coho, CCC and S-CCC steelhead in the San Lorenzo-Soquel and Salinas subbasins. The researchers would use backpack electrofishing and beach seines to capture the fish and would observe them during snorkel surveys. Captured fish would be enumerated, measured, and examined. Scale samples would be taken from a limited subset of individuals. Some salmonids would be PIT-tagged for a mark-recapture abundance estimation and to assess movement patterns. Snorkel surveys would be used in place of capture whenever possible. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities.

Table 43. Requested Take Permit 16318-2R (LHIA=Listed hatchery intact adipose fin, C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release, O=Observe, H=Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality
CCC Coho	Juvenile	Natural	C/H/R	600	6
CCC Coho	Juvenile	Natural	O/H	400	0
CCC Steelhead	Juvenile	Natural	C/H/R	2,600	39
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	2,740	50
CCC Steelhead	Juvenile	Natural	O/H	2,400	0
S-CCC Steelhead	Juvenile	Natural	C/H/R	1,760	22
S-CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	80	0
S-CCC Steelhead	Juvenile	Natural	O/H	1,440	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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for these species (and their components) found in Table 28. Activities that would take fish that have already spawned or observe/harass juveniles and pre-spawn adults are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 44. Percentage of the Estimated Annual Abundance of Juveniles, by ESU/DPS and Origin, Likely to be Killed by Permit 16318-2R.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CCC Coho	Juvenile	Natural	0.007
CCC Steelhead	Juvenile	Natural	0.03
S-CCC Steelhead	Juvenile	Natural	0.03

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. This project anticipates killing six juvenile CCC coho, 89 juvenile CCC steelhead and 22 S-CCC steelhead which represents less than 0.007, 0.03 and 0.03 percent of the population. Overall, the research would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Furthermore, the effects of the research is likely to be even smaller than what we analyzed as the juvenile mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality.
An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to assess salmonid habitat, presence, and abundance in order to inform watershed management and establish baseline population abundances before habitat conservation measures are implemented. This research would benefit listed species by providing population, distribution and habitat data that will be used to draft a Habitat Conservation Plan for the City of Santa Cruz.

Permit 10093-2R

Under permit 10093-2R, the CDFW is seeking to renew a five-year permit to take adult and juvenile CC Chinook, CCC and SONCC coho, and NC, S-CCC, SC and CCC steelhead. Fish would be captured by backpack electrofishing, beach seine, minnow traps, and weirs, and they would be observed during snorkel and spawning ground surveys. Some fish would be anesthetized, measured, weighed, tagged, and tissue sampled for genetic information. The researchers do not expect to kill any listed salmonids but a small number may die as an unintended result of the research activities.

Table 45. Requested Take Permit 10093-2R (C=Capture, H=Handle, T=Tag, TS=Tissue Sample, R=Release, O/H=Observe/Harass).

ESU/ Species	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortality*
CC Chinook	Juvenile	Natural	C/H/R	1,250	11
CC Chinook	Juvenile	Natural	C/H/T/TS/R	7,200	72
CC Chinook	Juvenile	Natural	O/H	5,000	0
CC Chinook	Adult	Natural	C/H/T/TS/R	50	1
CC Chinook	Adult	Natural	O/H	4,100	0
CC Chinook	Spawned Adult/ Carcass	Natural	O/H	100	0
CC Chinook	Spawned Adult/ Carcass	Natural	O/TS	6,100	0
CCC Coho	Juvenile	Natural	C/H/R	33,250	331
CCC Coho	Juvenile	Natural	C/H/T/TS/R	25,200	252
CCC Coho	Juvenile	Natural	O/H	4,500	0
CCC Coho	Adult	Natural	C/H/T/TS/R	1,000	10
CCC Coho	Adult	Natural	O/H	2,000	0
CCC Coho	Spawned Adult/ Carcass	Natural	O/H	100	0
CCC Coho	Spawned Adult/ Carcass	Natural	O/TS	2,500	0
SONCC Coho	Juvenile	Natural	C/H/R	1,300	11
SONCC Coho	Juvenile	Natural	C/H/T/TS/R	1,200	12
SONCC Coho	Juvenile	Natural	O/H	4,5000	0
SONCC Coho	Adult	Natural	O/H	2,000	0
SONCC Coho	Spawned Adult/ Carcass	Natural	O/H	100	0
SONCC Coho	Spawned Adult/ Carcass	Natural	O/TS	1,900	0
CCC Steelhead	Juvenile	Natural	C/H/R	550	11
CCC Steelhead	Juvenile	Natural	C/H/T/TS/R	150	2
CCC Steelhead	Juvenile	Natural	O/H	2,000	0
CCC Steelhead	Spawned Adult/ Carcass	Natural	O/H	50	0
NC Steelhead	Juvenile	Natural	C/H/R	24,550	241
NC Steelhead	Juvenile	Natural	C/H/T/TS/R	16,400	171
NC Steelhead	Juvenile	Natural	O/H	5,000	0
NC Steelhead	Adult	Natural	C/H/T/TS/R	200	2
NC Steelhead	Adult	Natural	O/H	1,700	0

NC Steelhead	Spawned Adult/ Carcass	Natural	O/H	50	0
NC Steelhead	Spawned Adult/ Carcass	Natural	O/TS	300	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 effect of these losses for the juvenile and adult fish, it is necessary to compare them to the total number of outmigrants and adult returns expected for these species (and their components) found in Table 28. Activities that would take fish that have already spawned or observe/harass juveniles and pre-spawn adults are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 46. Percentage of the Estimated Annual Abundance of Juveniles, by ESU/DPS and Origin, Likely to be Killed by Permit 10093-2R.

ESU/ Species	Life Stage	Origin	Percent (%) Mortalities
CC Chinook	Juvenile	Natural	0.006
CC Chinook	Adult	Natural	0.01
CCC Coho	Juvenile	Natural	0.6
CCC Coho	Adult	Natural	0.49
SONCC Coho	Juvenile	Natural	0.002
CCC Steelhead	Juvenile	Natural	0.005
NC Steelhead	Juvenile	Natural	0.05
NC Steelhead	Adult	Natural	0.03

Because the research would be spread out across various Coastal California streams, 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 abundance information for all of the coastal streams. We therefore compare the number of fish that may be killed by the research to the abundance of the ESU/DPS. With the exception of coho, at the salmon ESU/steelhead DPS levels, the permitted activities may kill, at most, 0.05 percent of the estimated outmigration for any ESU/DPS by origin.

Overall, the research would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Furthermore, the effects of the research is likely to be even smaller than what we analyzed as the mortality and take for each permit are estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality. Further, those small losses would take place in the context of generating information to be used in species recovery; this research will provide critical information on the abundance and timing of listed fish coastal California watersheds.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The project goal is to restore salmon and steelhead productivity in coastal California streams through a comprehensive restoration program. The specific goals of this research project are to assess and monitor streams to assess fish abundance and distribution. This research would benefit listed species by providing data to assess restoration projects and direct future habitat restoration needs.

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 action area falls entirely with within navigable waters, 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, all 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 47), (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 48).

Table 47. 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	Total Take	Percent (%) of Abundance	Lethal Take	Percent (%) of ESU/DPS Killed
CVSR Chinook	Adult	LHAC	125	1.5220	2	0.0244
		Natural	85	0.7412	2	0.0174
	Juvenile	LHAC	3865	0.1343	69	0.0000
		Natural	2193	0.0919	42	0.0018
SRWR Chinook	Adult	LHAC	50	23.2558	0	0.0000
		Natural	10	0.4748	0	0.0000
	Juvenile	LHAC	4110	2.1196	72	0.0371
		Natural	1248	0.7711	77	0.0476
CC Chinook	Adult	Natural	110	1.5638	3	0.0426
	Juvenile	Natural	9285	0.7265	110	0.0086

CCC Coho	Adult	LHIA	1325	*	27	*
		Natural	1425	87.9087	18	1.1104
	Juvenile	LHIA	27680	11.0720	552	0.2208
		Natural	83675	92.9722	1091	1.2122
SONCC Coho	Juvenile	LHIA	80	0.0139	0	0.0000
		Natural	2590	0.2352	24	0.0022
CCV Steelhead	Adult	LHAC	151	3.9160	3	0.0778
		Natural	221	13.1079	2	0.1186
	Juvenile	LHAC	3455	0.2158	60	0.0037
		Natural	5174	0.8207	175	0.0278
CCC Steelhead	Adult	LHAC	475	12.2866	10	0.2587
		Natural	1025	46.8679	10	0.4572
	Juvenile	LHAC	9580	1.4764	190	0.0293
		LHIA	6200	*	124	*
		Natural	42288	16.9988	881	0.3541
NC Steelhead	Adult	Natural	200	2.7697	2	0.0277
	Juvenile	Natural	41030	4.9952	412	0.0502
S-CCC Steelhead	Juvenile	Natural	2649	3.3507	52	0.0658
SC Steelhead	Adult	Natural	20	*	0	*
	Juvenile	Natural	210	*	12	*
Sturgeon	Adult	Natural	23	1.7062	0	0.0000
	Juvenile	Natural	420	*	11	*

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

Thus the activities contemplated in this opinion may kill—in combination and at most—as much as 1.21 percent of the fish from any component of any listed species. With the exception of CCC coho, at the salmon ESU/steelhead DPS levels, the permitted activities may kill, at most, 0.5 percent of the estimated outmigration for any ESU/DPS by origin. For CCC coho, we estimated that the permitted activities may kill as much as 1.2% of the estimated population. The majority of the CCC coho take contemplated in this opinion is for the CDFW project 10093-2R (Table 45). We think that 1.2% is an overestimate because (1) the data that CDFW is collecting suggests that the population estimates we used in this opinions are much lower than the existing populations and (2) CDFW reports taking ~1/3 of the take authorized previously under this permit.

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 48).

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 actions in this opinion—would have the following impacts in terms of the fish that may be killed.

Table 48. 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	Total Take	Percent (%) of Abundance	Lethal Take	Percent (%) of ESU/DPS Killed
CVSR Chinook	Adult	LHAC	28,357	345.2697	474	5.7713
		Natural	3548	30.9383	79	0.6889
	Juvenile	LHAC	20,005	0.6950	2,886	0.0000
		Natural	866,263	36.3061	16,730	0.7012
SRWR Chinook	Adult	LHAC	237	110.2326	53	24.6512
		Natural	271	12.8680	11	0.0000
	Juvenile	LHAC	15,643	8.0676	1,517	0.7824
		Natural	176,729	109.1998	5,064	3.1290
CC Chinook	Adult	Natural	1067	15.1692	35	0.4976
	Juvenile	Natural	547,138	42.8094	5,742	0.4493
CCC Coho	Adult	LHIA	1582	*	37	*
		Natural	3,128	192.9673	44	2.7144
	Juvenile	LHIA	103,551	41.4204	2,316	0.9264
		Natural	219,536	243.9289	4,115	4.5722
SONCC Coho	Juvenile	LHIA	7,930	1.3791	706	0.0000
		Natural	178,128	16.1731	2,392	0.2172
CCV Steelhead	Adult	LHAC	2,181	56.5612	97	2.5156
		Natural	3,617	214.5314	87	5.1601
	Juvenile	LHAC	15,465	0.9662	884	0.0552
		Natural	64,923	10.2987	2,080	0.3299
CCC Steelhead	Adult	LHAC	1852	47.9048	36	0.9312
		Natural	2,458	112.3914	37	1.6918
	Juvenile	LHAC	217,669	33.5448	5163.00	0.7957
		LHIA	6,200	*	124	*
		Natural	266,443	107.1037	6,124	2.4617

NC Steelhead	Adult	Natural	3,528	48.8575	14	0.1939
	Juvenile	Natural	421,354	51.2977	5,383	0.6554
S-CCC Steelhead	Adult	Natural	217	31.2230	5	0.7194
	Juvenile	Natural	39,452	49.9032	1122	1.4192
SC Steelhead	Adult	Natural	30	*	0	*
	Juvenile	Natural	3,000	*	87	*
Sturgeon	Adult	Natural	199	11.5727	4	0.3
	Juvenile	Natural	2,115	*	119	*
	Larvae	Natural	7,015	*	1,032	*
	Egg	Natural	1,526	*	1,526	*

** 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 six 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 5.8 percent of estimated species abundance—depending on the origin and life stage (Table 48). The 5.8 percent potential mortality figure is for adult Listed Hatchery Adipose Clipped origin fish that have no take prohibitions because they are considered surplus to recovery needs. The potential mortality for natural origin CVSR Chinook salmon would range from 0.68 to 0.70 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. Just 2.5 percent (2/79) of the adult natural origin CVSR Chinook salmon mortality and 0.25 percent (42/16,730) 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. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 23 percent of the naturally produced CVSR Chinook they requested and the actual mortality was only 17 percent of 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 48). The 24.7 percent potential mortality figure is for adult Listed Hatchery Adipose Clipped origin fish that have no take prohibitions because they are considered surplus to recovery needs. The potential mortality for natural origin SRWR Chinook salmon would range from 0 to 3.1 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. Just zero percent (0/11) of the adult natural origin SRWR Chinook salmon mortality and 1.5 percent (77/5,064) of the juvenile natural origin SWRW 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. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 12 percent of the naturally produced SRWR Chinook they requested and the actual mortality was only 6 percent of 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 48), the potential mortality for CC Chinook salmon would range from 0.45 percent to 0.49 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, only 8.6 percent (3/35) of the adult CC Chinook salmon mortality, and 1.9 percent (110/5,742) 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. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 42 percent of the CC Chinook they requested and the actual mortality was only 27 percent of requested. This would mean that the actual effect is likely to be 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 4.6 percent of estimated species abundance—depending on the origin and life stage (Table 48). The potential mortality for natural origin CCC coho salmon would range from 2.71 percent of estimated species abundance for adults to 4.57 percent of estimated species abundance for juveniles. In this case the projected total lethal take for all research and monitoring activities represents a considerable percent of the species' total abundance. The activities contemplated in this opinion represent, in some cases, a significant portion of this potential mortality. That is, 41 percent of the adult natural origin CCC coho salmon mortality, 27 percent of the juvenile natural origin CCC coho salmon mortality would result from activities contemplated in this opinion.

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 five years researchers, on average, ended up taking 6 percent of the CCC coho they requested and the actual mortality was only 2 percent of 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 to 0.2 percent of estimated species abundance—depending on the origin and life stage (Table 48). 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) and one percent (24/2,392) 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, on average, ended up taking 6 percent of the SONCC coho they requested and the actual mortality was only 3 percent of requested.

California Central Valley steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for CCV steelhead would range from 0.06 to 5.2 percent of estimated species abundance—depending on the origin and life stage (Table 48). However, the activities contemplated in this opinion represent only fractions of the potential mortality analyzed. In fact, just 2.3 percent (2/87) of the adult natural origin CCV steelhead mortality, and 8.4 percent (175/2,080) 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 also reveals that for the same time period researchers, on average, ended up taking 14% of the naturally produced adult CCV steelhead they requested and the actual mortality was only 0.4% of 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 0.8 to 2.5 percent of estimated species abundance—depending on the life stage (Table 48). The percent potential mortality for Listed Hatchery Adipose Clipped origin fish ranges from 0.8 to 0.9 percent, but take prohibitions do not apply for these components in any case. The potential mortality for natural origin CCC steelhead would range from 1.7 to 2.5 percent of estimated species abundance—depending on age class. The activities contemplated in this opinion represent only fractions of the potential mortality rates. In fact, 27 percent (10/37) of the adult natural origin CCC steelhead mortality, and 14 percent (881/6,124) 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 five years researchers, on average, ended up taking 15 percent of the CCC steelhead they requested and the actual mortality was only 7 percent of requested. 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 0.19 to 0.65 percent of estimated species abundance—depending on the life stage (Table 48). 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, 14.3 percent (2/14) of the adult natural origin NC steelhead mortality, and 7.6 percent (412/5,383) 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 five years researchers, on average, ended up taking 47 percent of the NC steelhead they requested and the actual mortality was only 15 percent of requested. 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 0.72 to 1.4 percent of estimated species abundance—depending on the age class (Table 48). 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 4.6 percent (52/1,122) 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 five years researchers, on average, ended up taking 8 percent of the S-CCC steelhead they requested and the actual mortality was only 3 percent of requested. 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 but the mean number of adult observations of SC steelhead annually is as low as 11 individuals, and an estimate of outmigrants based on these 11 returns is 1,262 juvenile individuals. Given these minimum estimates for anadromous outmigrants, the mortality of 87 juvenile individuals would constitute 6.9 percent of the run. No adult fish are expected to die as a result of research take. For the juvenile component, 13.8 percent (12/87) of the juvenile SC steelhead mortality would result from activities contemplated in this opinion. Therefore, most of the proposed potential juvenile mortality has been previously analyzed and found not to jeopardize the species. That is, the great majority of the take contemplated in this opinion, at least for the adult components, would have no effect on the species viability.

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 five years researchers, on average, ended up taking 8 percent of the SC steelhead they requested and the actual mortality was only 1 percent of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

For all of the research contemplated in this opinion, many of the juvenile salmon and steelhead that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above.

Still, considering that all of the take contemplated in this opinion for the adult components would have no effect whatever on the species viability, 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. 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

The majority of sturgeon handled subsequently recover shortly after handling with no long-term ill effects (no more than 2% of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality. When combined with the baseline, research authorizations may kill up to 1,526 eggs, 1,032 larvae, and 119 juvenile sturgeon (only 11 juvenile mortalities would result from the project considered in this opinion). The annual abundance of green sturgeon eggs and larvae is currently unknown due to a lack of knowledge of the survival rate of early life history stages of green sturgeon. However, given an annual spawning run estimate of 292 individuals, and a mean green sturgeon fecundity of 142,000 (Van Eenennaam et al. 2001), it can be safely assumed that the egg, larvae, and juvenile mortalities would represent a small fraction of the annual abundance of those life stages for the DPS.

When requested take of adult sturgeon is combined with the baseline the potential mortality would equal only 0.4% of the estimated abundance of adult sturgeon. Thus, the projected total lethal take for all research and monitoring activities represents only a very small percent of the species' total abundance. 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. 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% of the sDPS they requested and the actual mortality was only 8% 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.
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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

As noted in the sections on species status, no listed species currently has all its biological requirements being met. Their status is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. In addition, while the future impacts of cumulative effects are uncertain at this time, they are likely to continue to be negative. Nonetheless, in no case would the proposed actions exacerbate any of the negative cumulative effects discussed (habitat alterations, etc.) and in all cases the research may eventually help to limit adverse effects by increasing our knowledge about the species' requirements, habitat use, and abundance. The effects of climate change are also likely to continue to be negative. However, given the proposed actions' short time frames and limited areas, those negative effects, while somewhat unpredictable, are too small to be effectively gauged as an additional increment of harm over the time span considered in this analysis. Moreover, the actions would in no way contribute to climate change (even locally) and, in any case, many of the proposed actions would actually help monitor the effects of climate change by noting stream temperatures, flows, etc. So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that the proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in salmonid abundance would have no effect on increasing stream temperatures or continuing land development).

To this picture, it is necessary to add the increment of effect represented by the proposed actions. Our analysis shows that the proposed research activities would have slight negative effects on each species' abundance and productivity, but those reductions are so small as to have no more than a negligible effect on the species' survival and recovery. In all cases, the activity has never been identified as a threat, and the research is designed to benefit the species' survival in the long term.

For over two decades, research and monitoring activities conducted on anadromous salmonids in California have provided resource managers with a wealth of important and useful information regarding anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, and PIT-tagging efforts have increased the knowledge of anadromous fish abundance as we as migration timing and survival. By issuing research authorizations—including many of those being contemplated again in this opinion—NMFS has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions to sustain anadromous salmonid populations, mitigate adverse impacts on endangered and threatened salmon and steelhead, and implement recovery efforts. The resulting information continues to improve our knowledge of the respective species' life histories, specific biological requirements, genetic make-up, migration timing, responses to human activities (positive and negative), and survival in the rivers and ocean. And that information, as a whole, is critical to the species' survival.

Additionally, the information being generated is, to some extent, legally mandated. While no law calls for the work being done in any particular permit or authorization, 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.

Thus, 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, and sDPS green sturgeon, 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" Determinations

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.

2.11.1 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 are: 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 2008a).

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 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.

Southern Resident killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands. By early autumn, the range of the whales, particularly J pod, expands to Puget Sound. By late fall, the SR killer whales make frequent trips to the outer coast and are seen less frequently in the inland waters. In the winter and early spring, SR killer whales move into the coastal waters along the outer coast from southeast Alaska south to central California.

SRs consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their primary prey (review in NMFS 2008a). Ongoing and past diet studies of SRs conduct sampling during spring, summer and fall months in inland waters of Washington State and British Columbia (i.e., Ford and Ellis 2006; Hanson et al. 2010, ongoing research by the Northwest Fishery Science Center (NWFSC)). Therefore, the majority of our knowledge of diet is specific to inland waters. We know less about diet of SRs off the Pacific Coast. However, chemical analyses support the importance of salmon in the year-round diet of SRs (Krahn et al. 2002, Krahn et al. 2007). Prey and fecal samples recently collected in winter and spring indicates a diet dominated by salmonids, particularly Chinook salmon, with the presence of lingcod and halibut (NWFSC unpublished data). The predominance of Chinook salmon in the SRs' diet when 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 SRs predominantly consume Chinook salmon when available in coastal waters.

The proposed actions may affect SR killer whales indirectly by reducing availability of their primary prey, Chinook salmon. As described in the effects analysis for salmonids, approximately including 320 juvenile and 7 adult Chinook salmon may be killed during proposed research activities. Still, as the effects analysis illustrated, the newly proposed research as a whole is expected to have only very small effects on salmonid abundance and productivity and even smaller effects on diversity or distribution. Further, the adult salmonids that may be killed during the course of the research activities would not affect the whales' prey base because they would be taken after they have returned to freshwater and would therefore no longer be available as prey for the whales.

Nonetheless, the fact that the research would take some salmonids could affect prey availability to the whales in future years throughout their range, including in the critical habitat designated in the inland waters of Washington. The ten-year average smolt to adult ratio from coded wire tag 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 one percent (Schaller et al. 2007). If one percent of the 320 juvenile Chinook salmon that may be killed by the proposed research activities were to survive to adulthood, this would translate to the effective loss of no more than 3 adult Chinook salmon from a variety of runs across a 3-5 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). Further, the likelihood that any of these 6 adult Chinook salmon would have migrated into SR killer whale habitat, had they survived, is low, so it is most likely that few, if any, of the 6 adult Chinook salmon would ever even have the opportunity to become prey for the SRKWs.

In addition, the estimated mortality of Chinook is likely to be much smaller than stated. Our estimates of lethal take for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish will be killed by the research than stated. In fact, over the last five years researchers have only killed 12 percent of the allotted lethal take of juvenile Chinook salmon. Therefore, we derived the already small number of adults by overestimating the number of fish likely to be killed. Thus the actual reduction in prey available to the whales is undoubtedly smaller than the stated figures.

Given the total quantity of prey available to SR killer whales throughout their range, this reduction in prey is extremely small, and although measurable is not anticipated to be significantly different from zero (based on NMFS previous analysis of the effects of salmon harvest on SRs; e.g., NMFS 2008b). Because the reduction is so small, there is also a very low probability that any of the juvenile Chinook salmon killed by the research activities would have later (in 3-5 years' time) been intercepted by the killer whales across their vast range in the absence of the research activities. Therefore, the anticipated take of salmonids associated with the proposed actions would result in an insignificant reduction in adult equivalent prey resources for SR killer whales.

Similarly, the future loss of Chinook salmon could affect the prey PBF of designated critical habitat for killer whales. As described above, any salmonid take up to the aforementioned maximum extent and amount would result in an insignificant reduction in prey resources for SR killer whales that may intercept these species within their range and therefore would not affect the conservation value of the critical habitat.

Given these circumstances, and the fact that we anticipate no direct interaction between the researchers and the SR killer whales, NMFS finds that potential adverse effects of the proposed research on SRs are insignificant and determines 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, in part, on descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 kilometers) offshore of Washington, Oregon, and California north of Point Conception. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically, accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC) and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

This analysis is based, in part, on the descriptions of EFH for Pacific coast salmon contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.2 Adverse Effects on Essential Fish Habitat

As the biological opinion above describes, the proposed research actions are not likely, singly or in combination, to adversely affect the habitat upon which Pacific salmon, ground fish, and coastal pelagic species depend upon. All the actions are of limited duration, minimally intrusive, and are entirely discountable in terms of their effects, short-or long-term, on any habitat parameter important to the fish.

3.3 Essential Fish Habitat Conservation Recommendations

No conservation recommendations are necessary.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Given that there are no conservation recommendations, there is no statutory response requirement.

3.5 Supplemental Consultation

The action agency must reinitiate EFH consultation with if the proposed action is 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 600.920(l)].

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.

5. REFERENCES

5.1 Federal Register Notices

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

November 20, 1991 (56 FR 58612). Notice of Policy: Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon.

June 16, 1993 (58 FR 33212). Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon.

January 4, 1994 (59 FR 440). Final Rule: Endangered and Threatened Species; Status of Sacramento River Winter-run Chinook Salmon.

August 18, 1997 (62 FR 43937). Final Rule: Endangered and Threatened Species: Listing of Several Evolutionarily Significant Units (ESUs) of West Coast Steelhead.

March 19, 1998 (63 FR 13347). Final Rule: Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California.

March 23, 1999 (64 FR 14067). Endangered and Threatened Species; Regulations Consolidation.

May 5, 1999 (64 FR 24049). Final Rule: Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California.

September 16, 1999 (64 FR 50394). Final Rule. Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California.

June 7, 2000 (65 FR 36074). Final Rule: Endangered and Threatened Species; Threatened Status for One Steelhead Evolutionarily Significant Unit (ESU) in California.

January 9, 2002 (67 FR 1116). Final Rule: Governing Take of Four Threatened Evolutionarily Significant Units (ESUs) of West Coast Salmonids.

June 28, 2005 (70 FR 37160). Final Rule: Endangered and Threatened Species; Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

September 2, 2005 (70 FR 52488). Final Rule: Endangered and Threatened Species: Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California.

November 18, 2005 (70 FR 69903). Final Rule: Endangered Status for Southern Resident Killer Whales.

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

April 7, 2006 (71 FR 17757). Final Rule: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon.

November 29, 2006 (71 FR 69054). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale.

February 11, 2008 (73 FR 7816). Final Rule: Endangered and Threatened Species: Final Threatened Determination, Final Protective Regulations, and Final Designation of Critical Habitat for Oregon Coast Evolutionarily Significant Unit of Coho Salmon.

October 9, 2009 (74 FR 52300). Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon.

March 18, 2010 (75 FR 13012). Final Rule: Threatened Status for Southern Distinct Population Segment of Eulachon.

August 15, 2011 (76 FR 50447). Notice of availability of 5-year reviews: Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant 96 Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California.

October 20, 2011 (76 FR 65324). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon.

May 26, 2016 (81 FR 33468). Notice of availability of 5-year reviews for 17 evolutionarily significant units (ESUs) of Pacific salmon, 10 distinct population segments (DPSs) of steelhead (O. mykiss), and the southern DPS of eulachon.

5.2 Literature Cited

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser, and M. J. Parsley. 2007. Population status of North American green sturgeon, *Acipenser medirostris*. Environmental Biology of Fishes 79:339-356 pages.

Ainslie, B.J., J.R. Post, and A.J. Paul. 1998. Effects of Pulsed and Continuous DC Electrofishing on Juvenile Rainbow Trout. North American Journal of Fisheries Management:Vol. 18, No. 4, pp. 905–918.

Araki, H., W.R. Ardren, E. Olsen, B. Cooper, and M.S. Blouin. 2007. Reproductive success of captive-bred steelhead trout in the wild: evaluation of three hatchery programs in the Hood River. Conserv. Biol. 21: 181–190

Atkinson, K. A. 2010. Habitat conditions and steelhead abundance and growth in a California lagoon. San Jose State University, M.S. Thesis, San Jose, CA. 118 pp.

Bell, E.; Dagit, R., and L., Frank. 2011. Colonization and Persistence of a Southern California Steelhead (Oncorhynchus mykiss) Population. Bulletin of the Southern California Academy of Sciences: Vol. 110(1).

Bendock, T. and M.Alexandersdottir. 1993. Hooking mortality of Chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management 13:540-549 pages.

Bergman, P.K., K.B. Jefferts, H.F. Fiscus, and R.C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Washington Department of Fisheries, Fisheries Research Papers 3(1):63-84.

Bjorkstedt, E.P., B.C. Spence, J.C. Garza, D.G. Hankin, D. Fuller, W.E. Jones, J.J. Smith, and R. Macedo. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center. 210 pages.

Bordner, C.E., S.I. Doroshov, D.E. Hinton, R.E. Pipkin, R.B. Fridley, and F. Haw. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity. American Fisheries Society Symposium 7:293-303.

Botsford, L. W. and J. G. Brittnacher. 1996. Appendix C: Viability of Sacramento River Winter Run Chinook Salmon. Department of Wildlife, Fish, and Conservation Biology Center for Population Biology University of California Davis, CA. 34 pp.

Boughton, D., P. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Neilsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of the South-Central/Southern California: Population characterization for recovery planning. NOAA-Natl. Marine Fisheries Service, SW Fisheries Sci. Ctr. Tech. Memo. No. 394, Santa 28 Cruz, CA. 116 pp.

Boughton, D., P. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Neilsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2005. Contraction of the southern range limit for anadromous Oncorhynchus mykiss. NOAA-Natl. Marine Fisheries Service, SW Fisheries Sci. Ctr. Tech. Memo No. 380, 20 Santa Cruz, CA. 21 pp

Brewer, P.G. and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO^2 Problem. Scientific American. October 7, 2008.

Bruesewitz, S.L. 1995. Hook placement in steelhead. Technical Report No. AF95-01. Washington Department of Fish and Wildlife, Olympia.

Brynildson, O.M. and C.L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society 96:353-355.

Busby, P. B., T. C. Wainwright, G. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status Review: West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27.

CDFG (California Department of Fish and Game). 1965. California Fish and Wildlife Plan, Volume I: Summary. 110 pages.; Volume II: Fish and Wildlife Plans, 216 pages.; Volume III: Supporting Data, 1802 pages. Sacramento, CA.

CDFG (California Department of Fish and Game). 1990. Status and Management of Spring-Run Chinook Salmon. California Department of Fish and Game's Inland Fisheries Division, 33 pp.

CDFG (California Department of Fish and Game). 1998. A Status Review of the Spring-Run Chinook Salmon [Oncorhynchus Tshawytscha] in the Sacramento River Drainage. Candidate Species Status Report 98-01. California Department of Fish and Game.

CDFW (California Department of Fish and Wildlife). 2013b. Sacramento River Aerial Redd Surveys. Red Bluff, CA.

CDFW (California Department of Fish and Wildlife). 2015. CDFW News Release. Agencies Taking Measures to Protect Winter-run Chinook, Preparing to Release Approximately 600,000 Fish. Accessed online at https://cdfgnews.wordpress.com/2015/01/26/agencies-taking-measures-to-protect-winter-run-chinook-preparing-to-release-approximately-600000-fish/ on July 15, 2015.

Chilcote, M.W. 2003. Relationship between natural productivity and the frequency of wild fish in mixed spawning populations of wild and hatchery steelhead (Oncorhynchus mykiss). Canadian Journal of Fisheries and Aquatic Sciences 60:1057-1067. 2001–2003.

Chisholm, I.M. and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American fisheries Society 114:766-767.

CHSRG (California Hatchery Scientific Review Group). 2012. California Hatchery Review Report – Appendix VIII: Coleman National Fish Hatchery Steelhead Program Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. Available at: http://cahatcheryreview.com/wp-content/uploads/2012/08/Coleman%20Steelhead%20Program%20Report%20June%202012.pdf

Clark, G. H. 1929. Sacramento-San Joaquin Salmon (Oncorhynchus Tschawytscha) Fishery of California. Fish Bulletin 17.

Coble, D.W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31:173-180.

Conner, W.P., H.L. Burge, and R. Waitt. 2001. Snake River fall Chinook salmon early life history, condition, and growth as affected by dams. Unpublished report prepared by the U.S. Fish and Wildlife Service and University of Idaho, Moscow, ID. 4 p

Cox, P., and D. Stephenson. 2007. A changing climate for prediction. Science 113:207-208.

Cramer, S.P., C.F. Willis, S.C. Vigg, J.T. Hawksworth, R. Montagne, D. Cramer, F. Shrier, C. Phillips, J. Welty, and K. Reininga. 1997. Synthesis and analysis of the Lower Columbia River Steelhead Initiative. Special Report. S.P. Cramer and Associates, Gresham, OR.

Dalbey, S.R., T.E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury to long-term growth and survival of wild rainbow trout. North American Journal of Fisheries Management 16:560-569.

DeHaven, R. W. 2010. Adult and juvenile steelhead population surveys, Gualala River, California, 2010. 26 pp. Available at: http://vme.net/dvm/gualala-river/pdf/2010GRSSAnRepOnly.pdf

Dettlaff, T.A., A.S. Ginsburg, and O.I. Schmalhausen. 1993. Sturgeon Fishes: Developmental Biology and Aquaculture. Springer-Verlag, New York. 300 pages.

Duffy, W. G. 2011. Redwood Creek Life Cycle Monitoring – DIDSON. Final Project Report. Prepared for California Department of Fish and Game Fisheries Restoration Grants Program. Agreement No. P0810310. 12 pp.

Dwyer, W.P. and R.G. White. 1997. Effect of Electroshock on Juvenile Arctic Grayling and Yellowstone Cutthroat Trout Growth 100 Days after Treatment. North American Journal of Fisheries Management 17:174-177.

Eilers, C. D., J. Bergman, and R. Nelson. 2010. A Comprehensive Monitoring Plan for Steelhead in the California Central Valley. The Resources Agency: Department of Fish and Game: Fisheries Branch Administrative Report Number: 2010–2.

Erickson, D. L. and M. A. H. Webb. 2007. Spawning periodicity, spawning migration, and size at maturity of green sturgeon, Acipenser medirostris, in the Rogue River, Oregon. Environmental Biology of Fishes 79:255-268pages.

Ettlinger, E., M. Horowitz, B. Schleifer, G. M. Andrew. 2012. Lagunitas Creek Salmon Spawner Survey Report 2011-2012. Marin Municipal Water District, Corte Madera, CA. 21 pp.

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, and F.J. Millero. 2004. Impact of anthropogenic CO^2 on the $CaCO^3$ system in the oceans. Science 305: 362-366.

Fisher, F. W. 1994. Past and Present Status of Central Valley Chinook Salmon. Conservation Biology 8(3):870-873.

Fletcher, D.H., F. Haw, and P.K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-439.

Ford, J. K. B. and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus* orca in British Columbia. Marine Ecology Progress Series 316:185-199.

Fox, D.A., J.E. Hightower, and F.M. Parauka. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee River System, Alabama-Florida. Transactions of the American Fisheries Society 129:811-826.

Fredenberg, W.A. 1992. Evaluation of electrofishing-induced spinal injuries resulting from field electrofishing surveys in Montana. Montana Department of Fish, Wildlife and Parks, Helena.

Gallagher, S. P. and D. W. Wright. 2009. Coastal Mendocino County salmonid life cycle and regional monitoring: monitoring status and trends. California State Department of Fish and Game, Coastal Watershed Planning and Assessment Program, 1487 Sandy Prairie Court, Suite A, Fortuna, CA 95540. 58 pp.

Gallagher, S. P. and D. W. Wright. 2011. Coastal Mendocino County salmonid life cycle and regional monitoring: monitoring status and trends for 2010. California State Department of Fish and Game, Coastal Watershed Planning and Assessment Program, 1487 Sandy Prairie Court, Suite A, Fortuna, CA 95540. 49 pp.

Gallagher, S. P. and D. W. Wright. 2012. Coastal Mendocino County salmonid life cycle and regional monitoring: monitoring status and trends for 2011. California State Department of Fish and Game, Coastal Watershed Planning and Assessment Program, 1487 Sandy Prairie Court, Suite A, Fortuna, CA 95540. 34 pp.

Gallagher, S. P. Thompson, S., and D. W. Wright. 2013. Coastal Mendocino County salmonid life cycle and regional monitoring: monitoring status and trends for 2012. 2011-12 Administrative Report. California State Department of Fish and Wildlife, Coastal Watershed Planning and Assessment Program, 1487 Sandy Prairie Court, Suite A, Fortuna, CA 95540. 47 pp.

Garza, J. C. and D. E. Pearse. 2008. Population Genetic Structure of Oncorhynchus Mykiss in the California Central Valley: Final Report for California Department of Fish and Game. University of California, Santa Cruz, and National Marine Fisheries Service, Santa Cruz, California.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-66. 598 pp.

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An Evaluation of Stocking Hatchery-Reared Steelhead Rainbow Trout (*Salmo Gairdnerii Gairdnerii*) in the Sacramento River System. Fish Bulletin 114.

Hanson, B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C. K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, S.K. Wasser, K.C. Balcomb, K. Balcomb-Bartok, J.G. Sneva and M.J. Ford. 2010. Species and stock identification of prey consumed by southern resident killer whales in their summer range. Endangered Species Research 11:69-82.

Harris, S.L., and S.Thompson. 2014. Final project performance report: Northern Region Anadromous Sport Fish Management and Research Grant 56 and 56a - North Central District Salmon and Steelhead Management (G1398060).

Hayes, M.L. 1983. Active capture techniques. Pages 123-146 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, MD.

Hayes, D.B., C.P. Ferreri, and W.W. Taylor. 1996. Active fish capture methods. Pages 193-220 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, MD.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America 101: 12422-12427.

Healey, M. C. 1991. The life history of Chinook salmon (*Oncorhynchus tshawytscha*). *In* C. Groot and L. Margolis (eds), Life history of Pacific salmon, p. 311-393. Univ. BC Press, Vancouver, BC.

Healey, M. C., and W. Ra Heard. 1984. Inter- and intra-population variation in the fecundity of chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to life history theory. Can. J. Fish. Aquat. Sci. 4l:474-483.

Hockersmith, E.E., W.D. Muir, and others. 2000. Comparative performance of sham radiotagged and PIT-tagged juvenile salmon. Report to U.S. Army Corps of Engineers, Contract W66Qkz91521282, 25 pp.

Hollender, B.A. and R.F. Carline. 1994. Injury to wild brook trout by backpack electrofishing. North American Journal of Fisheries Management 14:643-649.

Hooton, R.S. 1987. Catch and release as a management strategy for steelhead in British Columbia. *In* R. Barnhart and T. Roelofs, editors. Proceedings of Catch and Release Fishing: a Decade of Experience, a National Sport Fishing Symposium. Humboldt State University, Arcata, CA.

Howe, N.R. and P.R. Hoyt. 1982. Mortality of juvenile brown shrimp Penaeus aztecus associated with streamer tags. Transactions of the American Fisheries Society 111(3):317-325.

Israel, Joshua A.; Bando, K. J.; Anderson, Eric C.; May, Bernie. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (Acipenser medirostris). Canadian Journal of Fisheries and Aquatic Sciences, Volume 66, Number 9, 1 September 2009, pp. 1491-1504(14).

Jenkins, W.E. and T.I.J. Smith. 1990. Use of PIT tags to individually identify striped bass and red drum brood stocks. American Fisheries Society Symposium 7: 341-345.

Kahn, Jason, and Malcolm Mohead. 2010. A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-OPR-45, 62 p

Kamler, J.F. and K.L. Pope. 2001. Nonlethal Methods of Examining Fish Stomach Contents. Reviews in Fisheries Science 9(1):1-11.

Kieffer, M.C. and B. Kynard. 1996. Spawning of the shortnose sturgeon in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 125:179-186.

Killam, D. 2012. Chinook Salmon Populations for the Upper Sacramento River Basin in 2011. RBFO Technical Report No. 03-2012. 104 pp.

Koehler, J. and P. Blank. 2012. Napa River Steelhead and Salmon Monitoring Program – 2011-2012 Season. Napa County Resource Conservation District. Napa, CA. 24 pp.

Kohlhorst, D.W. 1979. Effect of first pectoral fin ray removal on survival and estimated harvest rate of white sturgeon in the Sacramento-San Joaquin estuary. California Fish and Game 65:173-177.

Kostow, K.E. 2009. Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies. Rev. Fish. Biol. Fisheries 19:9-31.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (Orcinus orca) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-54, U.S. Department of Commerce, Seattle, WA.

Krahn, M.M., M.B. Hanson, R.W. Baird, R.H. Boyer, D.G. Burrows, C.E. Emmons, J.K.B. Ford, L.L. Jones, D.P. Noren, P.S. Ross, G.S. Schorr, and T.K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin 54(12): 1903-1911.

Latta, F. F. 1977. Handbook of Yokuts Indians. Second edition. Bear State Books, Santa Cruz, CA.

Light, R.W., P.H. Adler, and D.E. Arnold. 1983. Evaluation of Gastric Lavage for Stomach Analyses. North American Journal of Fisheries Management 3:81-85.

Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. Rechisky, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2008. Marine migration of North American green sturgeon. Transactions of the American Fisheries Society 137:182-194.

Lindley, S. T., R. S. Schick. 2007. "Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin." San Francisco Estuary and Watershed Science 5(1).

Lindley, S. T., R. S. Schick, A. Agrawal, M. Goslin, T. E. Pearson, E. Mora, J. J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2006. Historical Population Structure of Central Valley Steelhead and Its Alteration by Dams. San Francisco Estuary and Watershed Science 4(1):19.

Lindley, S. T., R. S. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon Esus in California's Central Valley Basin. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-360.

Lindsay, R.B., R.K. Schroeder, and K.R. Kenaston. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24:367-378.

Luers, A.L., Cayan, D.R., and G. Franco. 2006. Our Changing Climate, Assessing the Risks to California. A summary report from the California Climate Change Center. 16 pages.

Matthews, K.R. and R.H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium 7:168-172.

MacFarlane, RB, Norton, EC. 2002. Physiological ecology of juvenile chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and the Gulf of the Farallones, 343 CA. Fishery Bulletin 100:244-257.

Mattole Salmon Group. 2011. Spawning Ground Surveys, 2010-2011 Season Mattole River Watershed – Final Report. Petrolia, CA. 41 pp. Available at: http://www.mattolesalmon.org/images/stories/Documents/Reports/MSG/SpSur/Sp%20Report%202010-11.pdf

McCabe, G.T., and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Department of Fish and Game 76(4):248-250.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce., NOAA Tech. Memo NMFS-NWFSC-42.

McEwan, D. 2001. Central Valley steelhead. Contributions to the biology of Central Valley salmonids. California Department of Fish and Game Fish Bulletin 179(1):1-44.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, CA.

McMichael, G.A. 1993. Examination of electrofishing injury and short-term mortality in hatchery rainbow trout. North American Journal of Fisheries Management 13:229-233.

McMichael, G.A., L. Fritts, and T.N. Pearsons. 1998. Electrofishing Injury to Stream Salmonids; Injury Assessment at the Sample, Reach, and Stream Scales. North American Journal of Fisheries Management 18:894-904.

McNeil, F.I. and E.J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge (*Esox masquinongy*). Transactions of the American Fisheries Society 108:335-343.

Mears, H.C. and R.W. Hatch. 1976. Overwinter survival of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society 105:669-674.

Meehan, W.R. and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. J. Fish. Res. Board Can. 35:1359-1363.

Mellas, E.J. and J.M. Haynes. 1985. Swimming performance and behavior of rainbow trout (Salmo gairdneri) and white perch (*Morone americana*): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Metheny, M., and W. Duffy. 2014. Sonar estimation of adult salmonid abundance in Redwood Creek, Humboldt County, California 2012-2013. Report for California Department of Fish and Wildlife Fisheries Restoration Grants Program.

Mongillo, P.E. 1984. A summary of salmonid hooking mortality. Washington Department of Game, Olympia.

Moring, J.R. 1990. Marking and tagging intertidal fishes: review of techniques. American Fisheries Society Symposium 7:109-116.

Morrison, J. and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management 7:439-441.

Moser, M. and S. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Moyle, P. B. 2002. Inland Fishes of California. Revised and Expanded. Univ. Calif. Press, Berkeley and Los Angeles, CA.

Moyle, P. B., J. A. Israel, and S. E. Purdy. 2008. Salmon, Steelhead, and Trout in California – Status of an Emblematic Fauna. UC Davis Center for Watershed Sciences. Davis, CA. 316 pp.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 pp.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and growth of Klamath River green sturgeon (Acipenser medirostris). U.S. Fish and Wildlife Service Project 93-FP-13, Yreka, CA. 20 pages.

Naman, S. 2008. Predation by hatchery steelhead on natural salmon fry in the upper-Trinity River, California Thesis (M.S.)--Humboldt State University, Natural Resources: Fisheries. Arcata, CA.

NMFS (National Marine Fisheries Service). 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act, June 2000. Available at http://www.nwr.noaa.gov/1salmon/salmesa/4ddocs/final4d/electro2000.pdf.

NMFS (National Marine Fisheries Service). 2003. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation on: 1) Issuance of an incidental take statement (ITS) to the USFWS; 2) Issuance of an ITS to the BPA and the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation); and 3) Issuance of permit 1347 jointly to the Washington Department of Fish and Wildlife (WDFW), the Public Utility District No. 1 of Chelan

County (Chelan PUD), and the Public Utility District No. 1 of Douglas County (Douglas PUD). NMFS, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2005. Green sturgeon (Acipenser medirostris) status review update. NMFS, Southwest Fisheries Science Center, Long Beach, CA. 31 pp.

NMFS (National Marine Fisheries Service). 2007. North-central California coast recovery domain. 5-year review: Summary and evaluation of central California coastal steelhead DPS, northern California steelhead DPS. National Marine Fisheries Service, Southwest region, Long Beach, CA.

NMFS (National Marine Fisheries Service). 2008a. Recovery Plan for Southern Resident Killer Whales (Orcinus orca). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2008b. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Consultation on the Approval of revised Regimes under the Pacific Salmon Treaty and the Deferral of Management to Alaska of Certain Fisheries Included in those Regimes. December 22, 2008. F/NWR/2008/07706.

NMFS (National Marine Fisheries Service). 2009. Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan. November 30, 2009.

NMFS (National Marine Fisheries Service). 2011a. Endangered and Threatened Species. 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Poplation Segment of Steelhead in California. Federal Register 76(157):50447-50448.

NMFS (National Marine Fisheries Service). 2011b. Central Valley Recovery Domain 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon ESU. Southwest Region. 34 pp.

NMFS (National Marine Fisheries Service). 2011c. 5-Year Review: Summary and Evaluation of Central Valley Steelhead. U.S. Department of Commerce, 34 pp.

NMFS (National Marine Fisheries Service). 2011d. North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon ESU and Central California Coast Coho Salmon ESU. Southwest Region. 54 pp.

NMFS (National Marine Fisheries Service). 2012a. Public Draft Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, CA.

NMFS (National Marine Fisheries Service). 2012b. Public Review Draft South-Central California Coast Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA. 435 pp.

NMFS (National Marine Fisheries Service). 2012c. Final Recovery Plan for Central California Coast coho salmon Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2012d. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, CA. 19 pp.

NMFS (National Marine Fisheries Service). 2015. Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*), 5-Year Review: Summary and Evaluation. West Coast Region. Long Beach, CA. 41 pp.

NMFS (National Marine Fisheries Service). 2016a. 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionary Significant Unit. NOAA's National Marine Fisheries Service West Coast Region. April 2016.

NMFS (National Marine Fisheries Service). 2016b. 5-Year Status Review: Summary and Evaluation of Sacramento River Winter-Run Chinook Salmon ESU. NOAA's National Marine Fisheries Service West Coast Region. April 2016.

NMFS (National Marine Fisheries Service). 2016c. 5-Year Review: California Coastal Chinook Salmon and Northern California Steelhead. National Marine Fisheries Service West Coast Region. April 2016.

NMFS (National Marine Fisheries Service). 2016d. 5-Year Review: Southern Oregon/Northern California Coast Coho Salmon. National Marine Fisheries Service West Coast Region. April 2016.

NMFS (National Marine Fisheries Service). 2016e. 5-Year Review: Summary and Evaluation of Central California Coast Coho Salmon. National Marine Fisheries Service West Coast Region. April 2016.

NMFS (National Marine Fisheries Service). 2016f. 5-Year Review: Summary and Evaluation of Central Valley Steelhead Distinct Population Segment. National Marine Fisheries Service West Coast Region.

NMFS (National Marine Fisheries Society). 2016g. 2016 5-Year Review: Summary and Evaluation of Central California Coast Steelhead. National Marine Fisheries Service West Coast Region. April 2016.

NMFS (National Marine Fisheries Service). 2016h. 5-Year Review: Summary and Evaluation of South-Central California Coast Steelhead Distinct Population Segment. National Marine Fisheries Service. West Coast Region. California Coastal Office. Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2016i. San Joaquin River Restoration: San Joaquin River Spring-Run Chinook Salmon Reintroduction. Accessed at: http://www.westcoast.fisheries.noaa.gov/central_valley/san_joaquin/san_joaquin_reint.html on February 5, 2016.

Nicola, S.J. and A.J. Cordone. 1973. Effects of Fin Removal on Survival and Growth of Rainbow Trout (Salmon gairdneri) in a Natural Environment. Transactions of the American Fisheries Society 102(4):753-759.

Nielsen, L.A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23. Bethesda, Maryland 1992, 208pp.

Nielsen, J. L., S. Pavey, T. Wiacek, G. K. Sage, and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations 1999-2003. U.S.G.S. Alaska Science Center - Final Technical Report Submitted December 8, 2003. California Department of Fish and Game, Sacramento, California and US Fish and Wildlife Service, Red Bluff Fish, CA.

O'Farrell, M. R., M. S. Mohr, A. M. Grover, and W. H. Satterthwaite. 2012. Sacramento River winter Chinook cohort reconstruction: analysis of ocean fishery impacts. NOAA-TM-NMFS-SWFSC-491. 69 pp.

Osgood, K. E. (editor). 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. U.S. Dep. Commerce, NOAA Tech. Memo. NMFSF/ SPO-89, 118 pp.

Pauley, G. B., B. M. Bortz, and M. F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- steelhead trout. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.62). U.S. Army Corps of Engineers, TR EL-82-4. 24 pp.

Pearse, D.E., S. A. Hayes, M. H. Bond, C. V. Hanson, E.C. Anderson, R. B. Macfarlane, and J.C. Garza. 2009. Over the falls? Rapid evolution of ecotypic differentiation on steelhead/rainbow trout (*Oncorhynchus mykiss*). Journal of Heredity 100(5):515-525.

Peltz, L. and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium 7:244-252.

Pettit, S.W. 1977. Comparative reproductive success of caught-and-released and unplayed hatchery female steelhead trout (*Salmo gairdneri*) from the Clearwater River, Idaho. Transactions of American Fisheries Society 106(5):431-435.

PFMC (Pacific Fishery Management Council). 2013. Appendix B, Historical Record of Escapement to Inland Fisheries and Spawning Areas. Review of 2012 Ocean Salmon Fisheries (Document prepared for the Council and its advisory entities.) Pacific Fishery

Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

PFMC (Pacific Fishery Management Council). 2010. Review of 2009 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

PFMC (Pacific Fishery Management Council). 2009. Preseason Report 1: Stock Abundance analysis for 2009 Ocean Salmon Fisheries. Prepared for the Council and its advisory entities. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384

PFMC (Pacific Fishery Management Council). 1999. Appendix A, Amendment 14 to the Pacific Coast Salmon Plan; Identification and Description of Essential Fish Habitat, Adverse Impacts, and Recommended Conservation Measures for Salmon. PFMC, 2130 SW Fifth Avenue, Suite 224, Portland, OR 97201. http://www .pcouncil.org

Poytress, W.R., J.J. Gruber, and J.P. Van Eenennaam. 2010. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, CA.

Poytress, W. R., J. J. Gruber, and J. P. Van Eenennaam. 2012. 2011 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. US Fish and Wildlife Service.

Poytress, W. R., J. J. Gruber, C. Praetorius, and J. P. Van Eenennaam. 2013. 2012 Upper Sacramento River Green Sturgeon Spawning Habitat and Young-of-the-Year Migration Surveys. US Fish and Wildlife Service.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7: 317-322.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. Bonneville Power Administration, Portland, Oregon.

Prentice, E.F. and D.L. Park. 1984. A study to determine the biological feasibility of a new fish tagging system. Annual Report of Research, 1983-1984. Project 83-19, Contract DEA179- 83BP11982.

Radtke, L. D. 1966. Distribution of Smelt, Juvenile Sturgeon, and Starry Flounder in the Sacramento-San Joaquin Delta with Observations on Food of Sturgeon. In J.L. Turner and D.W. Kelly (Comp.) Ecological Studies of the Sacramento-San Joaquin Delta. Part 2 Fishes of the Delta. California Department of Fish and Game Fish Bulletin 136:115-129.

Quinn, T. P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. Published by University of Washington Press. Seattle, WA. 378 pp.

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Transactions of the American Fisheries Society 104(3):458-460.

Ricker, S.J. , D. Ward, and C. W. Anderson. 2014. Results of Freshwater Creek Salmonid Life Cycle Monitoring Station 2010-2013. California Department of Fish and Game, Anadromous Fisheries Resource Assessment and Monitoring Program, 50 Ericson Ct., Arcata, CA 95521.

Rondorf, D.W. and W.H. Miller. 1994. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River Basin. Prepared for the U.S. Dept. of Energy, Portland, OR. 219 p.

Rutter, C. 1904. The Fishes of the Sacramento-San Joaquin Basin, with a Study of Their Distribution and Variation. Pages 103-152 *in* Bill of U.S. Bureau of Fisheries.

Sandercock, F. K., 1991. Life history of coh salmon (*Oncorhynchus kisutch)*. *In* Pacific salmon life histories. *Edited by* C. Root and L. Marolis. UBC Press, Vancouver, BC. pp. 296 – 445.

Santa Ynez River Adaptive Management Committee. 2009. Summary and Analysis of Annual Fishery Monitoring in the Lower Santa Ynez River 1993-2004. Prepared for the Cachuma Conservation and Release Board.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus. 2002. Climate Change Impacts on U.S. Coastal and Marine Ecosystems. Estuaries, volume 25(2): 149-164.

Schaffter, R.G. 1997. White sturgeon spawning migrations and location of spawning habitat in the Sacramento River, California. California Fish and Game 83:1-20.

Schaller, H., P. Wilson, S. Haeseker, C. Peterosky, E. Tinus, T. Dalton, R. Woodin, E. Weber, N. Bouwes, T. Berggren, J. McCann, S. Rassk, H. Franzoni, P. McHugh. 2007. COMPARATIVE SURVIVAL STUDY (CSS) of PIT-Tagged Spring/Summer Chinook and Steelhead in the Columbia River Basin: Ten-year Retrospective Analyses Report. Project #1996-020-00, BPA Contract #s 25634, 25264, 20620. Project #1994-033-00, BPA Contract #25247.

Schill, D.J., and R.L. Scarpella. 1995. Wild trout regulation studies. Annual performance report. Idaho Department of Fish and Game, Boise.Seiler, D., G. Volkhardt, P. Topping, L. Kishimoto. 2002. 2000 Green River Juvenile Salmonid Production Evaluation. Washington Department of Fish and Wildlife.

Schisler, G.J. and E.P. Bergersen. 1996. Post release hooking mortality of rainbow trout caught on scented artificial baits. North American Journal of Fisheries Management 16(3):570-578.

Schneider, S. H. 2007. The unique risks to California from human-induced climate change. California State Motor Vehicle Pollution Control Standards; Request for Waiver of Federal Preemption, presentation. May 22, 2007.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2000. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1998 through September 1999. Annual progress report, Fish Research Project Oregon. Oregon Department of Fish and Wildlife, Portland.

Sharber, N.G. and S.W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management 8:117-122.

Sharber, N.G., S.W. Carothers, J.P. Sharber, J.C. DeVos, Jr. and D.A. House. 1994. Reducing electrofishing-induced injury of rainbow trout. North American Journal of Fisheries Management 14:340-346.

Sharpe, C.S., D.A. Thompson, H.L. Blankenship, C.B. Schreck. 1998. Effects of Routine Handling and Tagging Procedures on Physiological Stress Responses in Juvenile Chinook Salmon. The Progressive Fish-Culturist. 60(2):81-87.

Smith, D.M., Cusack, S., Colman, A.W., Folland, C.K., Harris, G.R., and Murphy, J.M. 2007. Improved surface temperature prediction for the coming decade from a global climate model. Science 317:796-799.

Snyder, D.E. 1992. Impacts of Electrofishing on fish. Contribution number 50 of the Larval Fish Laboratory, Colorado State University, Fort Collins.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, & R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. Corvallis, OR: ManTech Environmental Research Services Corp. TR-4501-96-6057.

Spence, B., E. Bjorkstedt, J. C. Garza, D. Hankin, J. Smith, D. Fuller, W. Jones, R. Macedo, T. H. Williams, and E. Mora. 2008. A framework for assessing the viability of threatened and endangered salmon and steelhead in North-Central California Recovery Domain. U. S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-SWFSC-423.

Spence B. C. and T. H. Williams. 2011. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Central California Coast Coho Salmon ESU. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-475

Spence, B.C. 2016. North-Central California Coast Recovery Domain. Pages 26 – 47 in T.H. Williams, B.C. Spence, D.A. Boughton, R.C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Stickney, R.R. 1983. Care and handling of live fish. Pages 85-94 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland, 468 pp.

Stolte, L.W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist 35:229-230.

Stone, L. 1872. Report of Operations During 1872 at the United States Salmon-Hatching Establishment on the Mccloud River, and on the California Salmonidae Generally; with a List of Specimens Collected.

Strange, C.D. and G.J. Kennedy. 1981. Stomach flushing of salmonids: a simple and effective technique for the removal of the stomach contents. Fish. Manage. 12:9-15.

TAC (U.S. v. Oregon Technical Advisory Committee). 2008. Biological assessment of incidental impacts on salmon species listed under the Endangered Species Act in the 2008-2017 non-Indian and treaty Indian fisheries in the Columbia River Basin.

Taylor, G., and R.A. Barnhart. 1999. Mortality of angler caught and released steelhead. California Cooperative Fish and Wildlife Research Unit, Arcata.

Taylor, M.J., and K.R. White. 1992. A meta-analysis of hooking mortality of non-anadromous trout. North American Journal of Fisheries Management 12:760-767.

Thompson, K.G., E.P. Bergersen, R.B. Nehring, and D.C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown and rainbow trout. North American Journal of Fisheries Management 17:154-159.

Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO^2 world. Mineralogical Magazine, February 2008, 72(1). 359-362.

USFWS. 2012. Memo: Planned release of brood year 2011 juvenile winter Chinook salmon from Livingston Stone National Fish Hatchery. 2 pp.

United States Fish and Wildlife Service and National Marine Fisheries Service (USFWS and NMFS). 1998. Endangered Species Act Consultation Handbook. Procedures for

Conducting Section 7 Consultations and Conferences. Final Draft. Washington, D.C. March.

Van Eenennaam, J. P., J. Linares, S. I. Doroshov, D. C. Hillemeier, T. E. Willson, and A. A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society 135:151-163.

Ward, B. R., and P. A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence in Keogh River steelhead trout, p. 209-217. In R. J. Gibson and R. E. Cutting [ed.] Production of juvenile Atlantic salmon, *Salmon salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. 118.

Waples, R. S. 1991. Defenition of "Species" Under the Endangered Species Act: Application to Pacific Salmon. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS, F/NWC-194. 29 pp.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.K. Teel, R.G. Kope, and R.S. Waples. 1995. Status Review of Coho Salmon from Washington, Oregon, and California. September 1995.

Welch H.E. and K.H. Mills. 1981. Marking fish by scarring soft fin rays. Canadian Journal of Fisheries and Aquatic Sciences 38:1168-1170.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L.G. Crozier, N.J. Mantua, M.R. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-564.

Williams, D. 2010. Harvest of species listed under the Endangered Species Act. Yurok Tribal Fisheries. March 2010. 9 p.

Williams, T. H., S. T. Lindley, B.C. Spence, and D.A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. 17 May 2011 – Update to 5 January 2011 report. National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, CA.

Williams, T.H., B. Spence, W. Duffy, D. Hillemeier, G. Kautsky, T. Lisle, M. McCain, T. Nickelson, E. Mora, and T. Pearson. 2008. Framework for assessing viability of threatened coho salmon in the Southern Oregon / Northern California Coasts Evolutionarily Significant Unit. NOAA Technical Memorandum NMFS-SWFSC-432

Williams, T.H., E.P. Bjorkstedt, W.G. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, M.N. Goslin, and A. Agrawal. 2006. Historical population structure of coho salmon in the Southern Oregon/Northern California Coasts Evolutionarily Significant Unit. NOAA-TM-NMFS-SWFSC-390. June 2006.

Wydoski, R.S. 1997. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 *in* R.A. Barnhart and T.D. Roelofs, editors. Proceedings of a national symposium on catch-and-release fishing as a management tool. Humboldt State University, Arcata, CA.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:485-521.

Yoshiyama, R.M., E.R.Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: final report to Congress. Pages 309-362 in Volume 3. Assessments, commissioned reports, and background information. University of California, Center for Water and Wildland Resources, Davis.

Zimmerman, C. E., G. W. Edwards, and K. Perry. 2009. Maternal Origin and Migratory History of Steelhead and Rainbow Trout Captured in Rivers of the Central Valley, California. Transactions of the American Fisheries Society 138(2):280-291.