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

Consultation on the Issuance of Thirteen ESA Section 10(a)(1)(A) Scientific Research Permits in California affecting Salmon, Steelhead, and Green Sturgeon in the West Coast Region

NMFS Consultation Number: WCRO-2019-02395
ARN 151422WCR2019PR00118

Action Agencies: The National Marine Fisheries Service (NMFS)
United States Fish and Wildlife Service (USFWS)
National Park Service (NPS)

Affected Species and 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?
Lower Columbia River (LCR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
California Coastal (CC) Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Central Valley spring-run (CVS) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Sacramento River (SacR) winter-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Central California Coast (CCC) coho salmon (*O. kisutch*)	Endangered	Yes	No	No	No
Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Northern California steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

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?
California Central Valley 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 DPS green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Southern Resident (SR) killer whale (*Orcinus orca*)	Endangered	No	No	No	No

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

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

Issued By: For Chris E. Yates

Barry A. Thom
Regional Administrator

Date: September 24, 2019

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List of Acronyms

ARN – Administrative Record Number
BACI – Before-After Control-Impact
BIA – Bureau of Indian Affairs
BPA – Bonneville Power Administration
CA – California
C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
CC – California Coastal
CCC – Central California Coast
CCV – California Central Valley
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulation
CH – Critical Habitat
CHART – Critical Habitat Analytical Review Teams
CHBT –California Halibut Bottom Trawl
CR – Columbia River
CVS – Central Valley spring-run
CVSR – Central Valley spring-run
CWT – Coded Wire Tag
DC – Direct Current
DIDSON – Dual Frequency Identification Sonar
DPS – Distinct Population Segment
DQA – Data Quality Act
EFH – Essential Fish Habitat
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
HES – Hagar Environmental Science
HUC5 – Hydrologic Unit Code (fifth-field)
IDFW – Idaho Department of Fish and Wildlife
IM – Intentional (Directed) Mortality
ITS – Incidental Take Statement
LCR – Lower Columbia River
LHAC – Listed Hatchery Adipose Clipped
LHIA – Listed Hatchery Intact Adipose
MBSTP – Monterey Bay Salmon and Trout Project
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NC – Northern California
NFH – National Fish Hatchery
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NWFSC – Northwest Fisheries Science Center
O/H – Observe/Harass
OC – Oregon Coast

ODFW – Oregon Department of Fish and Wildlife
OL – Ozette Lake
PBF – Physical or Biological Features
PCE – Primary Constituent Element
PFMC – Pacific Fishery Management Council
PIT – Passive Integrated Transponder
PS – Puget Sound
PTI – Puyallup Tribe of Indians
RK – River Kilometer
ROV – Remotely Operated Vehicle
RPA – Reasonable Prudent Alternatives
RPM – Reasonable and Prudent Measure
S – Southern
SacR – Sacramento River
SAR – Smolt-to-adult ratio
SCCC – South-Central California Coast
SDPS – Southern DPS
SF – South Fork
SONCC – Southern Oregon/Northern California Coast
SR – Southern Resident
SRKW- Southern Resident Killer Whale
SRWR – Sacramento River winter-run
ST/R – Sample Tissue/Release Live Animal
USFWS – United States Fish and Wildlife Service
VSP – Viable Salmonid Population
WCR – West Coast Region
WDFW – Washington Department of Fish and Wildlife

1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.) and implementing regulations at 50 CFR 402. It constitutes a review of thirteen scientific research permits NMFS proposes to issue under section 10(a)(1)(A) of the ESA and is based on information provided in the associated applications for the proposed permits, published and unpublished scientific information on the biology and ecology of listed salmonids 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). A complete record of this consultation is on file with the Protected Resources Division in Portland, OR.

1.2 Consultation History

The West Coast Region's (WCR's) Protected Resources Division (PRD) received thirteen applications for permits to conduct scientific research in California (see dates below; Table 1):

- Six applications were to renew existing permits
- Three applications were to modify existing permits, and
- Four applications were for new permits.

Because the permit requests are similar in nature and duration and are expected to affect many of the same listed species, we combined them into a single consultation pursuant to 50 CFR 402.14(c).

The affected species are:

- Chinook salmon
    - Lower Columbia River (LCR)
    - Central Valley spring-run (CVSR)
    - Sacramento River winter-run (SRWR)
    - California Coastal (CC)
- Coho salmon
    - Southern Oregon/Northern California Coast (SONCC)
    - Central California Coast (CCC)

- Steelhead
  - Northern California (NC)
  - California Central Valley (CCV)
  - Central California Coast (CCC)
  - South-Central California Coast (SCCC)
- Southern DPS (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. Analysis in support of that conclusion is found in the "Not Likely to Adversely Affect" Determination section (2.11).

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

Permit Number	Applicant
13791-6M	Lodi U.S. Fish and Wildlife Service Office
14808-4M	California Department of Fish and Wildlife
15169-2R	National Park Service
16344-3R	Oregon State University
16491-3R	Fawcett Ecological Consulting
16506-3R	Independent Researcher Mike Podlech
17551-3R	California Department of Fish and Wildlife
19400-3R	ICF Consulting
22270	Wiyot Tribe
22303	NMFS West Coast Region
22700	Monterey Bay Salmon and Trout Project
22939	TRPA Fish Biologists
16318-3M	Hagar Environmental Science

We received a permit modification request (13791-6M) from the Lodi Fish and Wildlife Office on February 25, 2019. Requested edits were sent, addressed, and the application was completed on March 26, 2019.

We received a permit modification request (14808-4M) from the California Department of Fish and Wildlife on March 27, 2019. Requested edits were sent, and all requests were addressed and completed by March 27, 2019.

We received a permit renewal request (15169-2R) from the National Park Service on March 30, 2018. Requested edits were sent, addressed, and the application was completed on June 5, 2019.

We received a permit renewal request (16344-3R) from the Oregon State University on December 31, 2018. Requested edits were sent, addressed, and the application was completed on June 5, 2019.

We received a permit renewal request (16491-3R) from Fawcett Ecological Consulting on August 16, 2018. Requested edits were sent, addressed, and the application was completed on March 28, 2019.

We received a permit renewal request (16506-3R) from Independent Researcher Mike Podlech on March 29, 2018. Requested edits were sent, addressed, and the application was completed on March 28, 2019.

We received a permit renewal request (17551-3R) from the California Department of Fish and Wildlife on April 11, 2018. Requested edits were sent, addressed, and the application was completed on April 17, 2019.

We received a permit renewal request (19400-3R) from ICF Consulting on August 10, 2018. Requested edits were sent, addressed, and the application was completed on April 17, 2019.

We received a permit request (22270) from the Wiyot Tribe on July 26, 2018. Requested edits were sent, addressed, and the application was completed on March 28, 2019.

We received a permit request (22303) from NMFS West Coast Region on December 19, 2018. Requested edits were sent, addressed, and the application was completed on March 28, 2019.

We received a permit request (22700) from the Monterey Bay Salmon and Trout Project on December 17, 2018. Requested edits were sent, addressed, and the application was completed on March 28, 2019.

We received a permit request (22939) from the TRPA Fish Biologists on March 12, 2019. Requested edits were sent, addressed, and the application was completed on June 10, 2019.

We received a permit modification request (16318-3M) from Hagar Environmental Science on July 15, 2019. Requested edits were sent, addressed, and the application was completed on August 2, 2019.

Most of the requests were deemed incomplete to varying extents when they arrived. After numerous phone call and e-mail exchanges, the applicants revised and finalized their applications. After the applications were determined to be complete, we published notice in the Federal Register on June 27, 2019 and August 2, 2019 asking for public comment on them (84 FR 30696 and 84 FR 37838). The public was given 30 days to comment on the permit applications and, once those periods closed on July 27, 2019 and September 3, 2019, the consultation began (formal initiation was on September 3, 2019). The full consultation histories for the actions are lengthy and not directly relevant to the analysis for the proposed actions and so are not detailed here. A complete record of this consultation is maintained by the PRD and kept on file in Portland, Oregon.

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). "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.

The proposed actions here are for NMFS to issue thirteen scientific research permits pursuant to section 10(a)(1)(A) of the ESA for the associated activities proposed by the applicants listed in Table 1. The permits would variously authorize researchers to take CC, CVS, LCR, and SRWR Chinook salmon; CCC and SONCC coho salmon; NC, CCC, CCV, and SCCC steelhead, and 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.

Permit 13791-6M

The Lodi office of the U.S. Fish and Wildlife Service (FWS) is seeking to modify a 5-year permit that currently allows them to take juvenile CVSR and SRWR Chinook salmon, juvenile CCV steelhead and juvenile green sturgeon in the lower Sacramento and San Joaquin Rivers and SF estuary, CA. The purposes of the research are to assess (1) abundance, temporal and spatial distribution, and survival of salmonids, (2) occurrence and habitat use of fishes within the Liberty Island and Cache Slough Complex, (3) relative gear efficiency for fish survey nets, and also the distribution of Delta smelt, (4) littoral habitat use of juvenile Chinook salmon within the Delta, (5) abundance and distribution of Delta smelt, (6) length at date race criteria of winter run sized and larger Chinook salmon, (7) winter and spring run sized Chinook salmon floodplain usage in the Yolo bypass, and (8) salmonid genetic monitoring. The FWS proposes to capture fish with seines (beach and purse), nets (fyke and gill), boat and backpack electroshocking, trawls (midwater and bottom), and with rotary screw traps. The FWS would also observe fish during snorkel and spawning ground surveys. A subset of the captured fish would be anesthetized, measured, weighed, tagged (acoustic or PIT), dye injected (tattoo, photonic) have a tissue sample taken, allowed to recover, and released. This modification is requested because the original permit application did not include take of adult salmon, however unintentional encounters with adult fish have occurred. The FWS is requesting take for adult SRWR and CVSR Chinook salmon, CCV steelhead, and sDPS green sturgeon. While the FWS does not target adult fish and would avoid them, encounters with adult fish could take place as an unintentional result of sampling.

Permit 14808-4M

The California Department of Fish and Wildlife (CDFW) is seeking to modify a 5-year permit that currently allows them to take juvenile and adult SRWR and CVSR Chinook salmon, CCV steelhead and green sturgeon in the Central Valley of CA. The purposes of the research are to (1) monitor the outmigration of juvenile salmonids on a real-time basis, (2) provide daily summaries of timing, abundance and size distribution of salmonids in the Sacramento River, (3) provide timing information to water agencies for better management decisions, (4) examine how environmental conditions (flow, temperature, turbidity) affect the downstream movement of juvenile salmonids, and (5) provide recommendations for the development of steelhead monitoring programs to assess restoration and recovery goals. The objectives of the steelhead monitoring program are to (1) estimate steelhead population abundance with estimated levels of precision in the Central Valley, (2) examine trends in steelhead abundance in the Central Valley, and (3) identify the spatial distribution of steelhead in the Central Valley to identify their current range and observe changes over time. The CDFW proposes to capture fish with rotary screw traps and to observe fish at weirs, fish ladders, dams and during snorkel surveys. Captured fish would be anesthetized, measured, weighed, tagged (acoustic, Floy, Elastomer, or PIT), have a tissue sample taken, allowed to recover, and released. The modification is requested because the original permit application included an indirect mortality rate of one percent for rotary screw trapping and the application is requesting a three percent indirect mortality rate. The researchers do not intend to kill any listed fish as part of the additional take requested from this modification, but some may die as an inadvertent result of the research.

Permit 15169-2R

The National Park Service (NPS) Point Reyes Station is seeking to renew for five years a research permit that currently allows them to take juvenile and adult CC Chinook salmon, CCC coho, and CCC steelhead along the central coast of California. The purposes of the research are to (1) monitor juvenile salmonid outmigration, (2) study the diet of juvenile salmonids, (3) document adult salmonid spawning, (4) study juvenile salmonid distribution and population abundance, (5) study winter habitat utilization, (6) document adult escapement, and (7) study fish movements in Tomales Bay. The NPS proposes to capture fish with nets (fyke, seine, beach), backpack electroshocking, weirs, and rotary screw traps and to observe fish during snorkel and spawning ground surveys. A subset of captured fish would be anesthetized, measured, weighed, tagged (acoustic, FLOY or PIT), dye injected (tattoo, photonic) have a tissue sample taken, have stomachs pumped for diet analysis, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16344-3R

The Oregon State University is seeking to renew for five years a research permit that currently allows them to take juvenile listed hatchery SONCC coho in the Upper Klamath River. The purposes of this research are to (1) determine the effects of infection by the myxozoan parasite *Ceratonova shasta* on coho salmon, and (2) estimate disease effects for each study year on the wild coho population. Juvenile coho salmon from Iron Gate and/or Trinity River hatcheries would be transported to selected locations on the Klamath River and monitored for disease after the exposure to *C. shasta.* Following exposure, all fish would be transported to the Oregon State University J. L. Fryer Aquatic Animal Health Laboratory where time to morbidity, overall morbidity and infection prevalence would be ascertained through microscopic and molecular analysis of intestinal tissues. Because all of the fish will be exposed to the parasite *C. shasta*, they can not be released after the experiments. In addition, infection prevalence data are needed which requires euthanizing all fish surviving the exposures, since surviving fish may still be infected with the parasite.

Permit 16491-3R

Fawcett Ecological Consulting is seeking to renew for five years a research permit that currently allows them to take juvenile CC Chinook salmon, CCC coho and CCC steelhead in coastal Northern California streams. The purposes of the research are to (1) monitor salmonid populations in Salmon Creek, Sonoma County, in relation to habitat restoration and coho restocking efforts, and (2) study the genetics, variability in abundance, and life histories of steelhead in small coastal streams. The applicant proposes to capture fish using beach seines and to observe fish during snorkel and spawning ground surveys. A subset of captured fish would be anesthetized, measured, weighed, tagged (FLOY), have a tissue sample taken, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16506-3R

Mike Podlech, an independent researcher, is seeking to renew for five years a research permit that currently allows him to take juvenile and adult CCC coho and steelhead in Squaw and Pescadero creeks in Sonoma and San Mateo counties. The purposes of the research are to (1) monitor CCC steelhead population trends in Squaw and Pescadero creeks, (2) assess whether previous coho salmon broodstock releases have resulted in wild progeny in Pescadero Creek, and (3) to gather population data to inform ongoing watershed restoration and salmonid recovery efforts in Pescadero Creek. The applicant proposes to capture fish with a fyke net and backpack electrofishing. A subset of the captured fish would be anesthetized, measured, weighed, have a tissue sample taken, allowed to recover, and released. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 17551-3R

The CDFW is seeking to renew for five years a research permit that currently allows them to take juvenile green sturgeon, adult CCV steelhead, and adult SRWR and CVSR Chinook salmon in the Sacramento-San Joaquin Delta in San Francisco Bay, CA. The purposes of the research are to (1) document juvenile green sturgeon movement, emigration patterns, and survival, and (2) to determine the timing of Pacific Ocean entry and subsequent ocean migration patterns. The applicant proposes to capture fish with a gill net. Captured green sturgeon would be anesthetized, measured, weighed, tagged (acoustic or sonic), have a tissue sample taken, allowed to recover, and released. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 19400-3R

ICF Consulting is seeking to renew for five years a research permit that currently allows them to take juvenile natural and listed hatchery SRWR and CVSR Chinook salmon, CCV steelhead and juvenile green sturgeon in Suisan Bay, CA. The purposes of the research are to (1) determine the spatial and temporal distribution and abundance of juvenile Chinook salmon in shallow water habitats and compare observed patterns to predictions from habitat suitability models, and (2) provide baseline fish and invertebrate samples for a Before-After Control-Impact (BACI) study design to assess the impact of a planned breach at the Tule Red restoration site. The applicant proposes to capture fish with seines (beach, Lampara), nets (fyke), and trawls (midwater, otter). Researchers would capture, handle, and release juvenile green sturgeon and intentionally euthanize small numbers of juvenile salmon for isotopic and otolith analysis as part of this study.

Permit 22270

The Wiyot tribe is seeking a five-year research permit that would allow them to annually take juvenile NC steelhead in the South Fork of the Eel River, CA. The purposes of the research are to (1) to evaluate the impacts of Sacramento pikeminnow, a non-native predator, on Pacific lamprey, steelhead, and other native species, and (2) to develop and test methods for pikeminnow population suppression in terms of catch-per-unit-effort and cost-per-fish captured. The applicant proposes to capture fish with backpack and boat electrofishing, fyke net, seine, baited frame traps, dip netting and hook-and line and to observe fish during snorkel surveys. A subset of captured fish would be anesthetized, measured, weighed, have a tissue sample taken, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 22303

The NOAA Fisheries California Central Valley office is seeking a five year research permit that would allow them to annually take adult LCR, SRWR, CVSR, and CC Chinook salmon, as well as subadult and adult green sturgeon. The purpose of the research is to test the use of DIDSON cameras to characterize the physical interaction between green sturgeon and the CA halibut bottom trawl fishery (CHBT) operating out of Half Moon and San Francisco bays. In a previous cooperative study conducted with CHBT fishermen, NOAA observers, NMFS Science Center staff, and the CDFW, satellite tags were used to measure green sturgeon post-release survival in the halibut fishery. In this study, researchers would test the use of DIDSON cameras in the CHBT nets to characterize the physical interaction between green sturgeon and CHBT nets. Study results would be used to evaluate methods to minimize gear interactions and bycatch of green sturgeon. The applicant proposes to capture fish with a bottom trawl. Captured green sturgeon would be captured, handled and released. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 22700

The Monterey Bay Salmon and Trout Project (MBSTP) is seeking a five-year research permit that would allow them to annually take adult CC coho and CCC steelhead in the San Lorenzo River, CA. The purpose of the research is to gather genetic and life history data on CCC steelhead in the San Lorenzo River watershed, a major supporting system for the Santa Cruz Mountains Diversity Stratum. This research will contribute to large-scale salmonid monitoring programs on the San Lorenzo River that are currently being implemented by the City and County of Santa Cruz.

Information gathered by this project on the genetic diversity, size and timing of steelhead runs in the San Lorenzo River will help provide the information necessary to facilitate recovery actions planned for the CCC DPS. The applicant proposes to capture fish at the Felton Diversion Facility weir. Captured adult steelhead would be measured, weighed, PIT tagged, have a tissue sample taken, allowed to recover, and released. Adult coho would be captured, handled and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 22939

Tim Salamunovich of TRPA Fish Biologist is seeking a 5-year research permit that would allow him to annually take juvenile SRWR and CVSR Chinook salmon, CCV steelhead and green sturgeon in a central valley delta wetland area known as The Big Ditch on the Peterson Ranch in eastern Solano County, California. The purpose of this research is to collect seasonal presence/absence and relative abundance data to document seasonal fish use throughout the project area in order to document the baseline conditions prior to restoration efforts. The applicant proposes to capture fish with beach seines and minnow traps. Captured fish would be anesthetized, measured, weighed, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16318-3M

Hagar Environmental Science (HES) is seeking to modify a 5-year permit that currently allows them to take juvenile and smolt CCC coho salmon, CCC steelhead, and SCCC steelhead in the San Lorenzo River (including Newell Creek, Zayante Creek, and Mountain Charlie Creek), Liddell Creek, Laguna Creek, and Majors Creek in Santa Cruz County, and in the Salinas River (including Arroyo Seco River, Nacimiento River, San Antonio River, and upper tributaries) in Monterey and San Luis Obispo Counties, CA. The purposes of the research are to provide ESA-listed salmonid population, distribution, and habitat assessment data to inform watershed management, as well as establish baseline population abundances preceding the implementation of habitat conservation measures. HES proposes to capture fish with beach seines and backpack electrofishing. Fish would be enumerated, measured, and observed for external condition. A subset of the captured fish would be anesthetized, measured, weighed, PIT tagged, have a tissue sample taken, allowed to recover, and released. HES would also observe fish during snorkel/dive surveys. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research. This modification is requested to increase the number of juvenile CCC steelhead because the researchers encountered greater numbers of CCC steelhead than were authorized in the existing permit.

Common Elements among the Proposed Permit 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 the NMFS' WCR issues 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 terms and conditions in the 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. The permit holder must stop handling listed juvenile fish if the water temperature exceeds 70 degrees Fahrenheit (^{o}F) at the capture site. Under these conditions, listed fish may only be visually identified and counted. In addition, electrofishing is not permitted if water temperature exceeds 64^{o}F.

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 the only activity is determining fish presence.

9. The permit holder using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (June 2000) (NMFS 2000).

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 the APPS permit website where downloadable forms can also be found. 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.

"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 the individual 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 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, each Federal agency must ensure that its 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 habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

This opinion constitutes formal consultation and an analysis of effects solely for the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this opinion.[1] Herein, the NMFS determined that the proposed action of issuing thirteen scientific research permits, individually or in aggregate:

- May adversely affect LCR, CVSR, SacR, and CC Chinook salmon; SONCC and CCC coho salmon; NC, CCV, CCC, and SCCC steelhead; and sDPS green sturgeon; but would not jeopardize their continued existence.
- Is not likely to adversely affect SR killer whales or critical habitat designated for any of the subject species. This conclusion is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.11).

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).

[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, it should be noted that the terms "artificially propagated" and "hatchery" are used interchangeably in the Opinion, as are the terms "naturally propagated" and "natural."

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.

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 expected 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.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA 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 PBFs that help to form that conservation value.

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). Events of both extreme precipitation and intense aridity are projected for California, increasing climactic volatility throughout the state (Swain et al. 2018). Snow pack is a major contributor to stored and distributed water in the state (Diffenbaugh et al. 2015), but this important water source is becoming increasingly threatened. 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). California wildfires are expected to increase in frequency and magnitude, with 77% more area burned by 2099 under a high emission scenario model (Westerling 2018). 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 (Williams et al. 2016). Estuaries may also experience changes detrimental to salmonids and green sturgeon. Estuarine productivity is likely to change based on alterations to freshwater flows, nutrient cycling, and sedimentation (Scavia et al. 2002). In marine environments, ecosystems and habitats important to subadult and adult green sturgeon and salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely et al. 2004, Brewer 2008, Osgood 2008, Turley 2008), which would be expected to negatively affect marine growth and survival of listed fish. The projections described above are for the mid- to late-21st Century. In shorter time frames, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007, Smith et al. 2007).

The earth's oceans are also warming, with considerable interannual and inter-decadal variability superimposed on the longer-term trend. 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 (Scheurell and Williams 2005; 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), as sea surface temperature increases of 1.1-3.6 ℃ are anticipated in the Northern Hemisphere by 2081-2100 (Williams et al. 2016). 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).

Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across California or the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (e.g. Mote et al. 2014, Mote 2016; Pierce et al. 2018). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013, Mote et al. 2014).

Temperatures for the state of California are projected to increase between 2 and 7°C in modeled medium and high emissions scenarios, respectively; seasonal precipitation will shift towards wetter winters (up to 20% precipitation increase) and drier spring and fall seasons (up to 20% precipitation decrease; Pierce et al. 2018). In the Pacific Northwest, warmingtemperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in Pacific Northwest summer precipitation of up to 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014).

Projections in the western United States show climate change will influence precipitation patterns. Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007, Mote et al. 2013, Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007, Mote et al. 2014). In California specifically, seasonal precipitation is anticipated to increase slightly in the winter months of December, January, and February, but decrease in the spring and fall months of March, April, May, September, October and November (Pierce et al. 2018). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009). Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al. 2011, Tillmann and Siemann 2011, Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999, Winder and Schindler 2004, Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright and Weitkamp 2013; Raymondi et al. 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Northwestern Pacific Ocean as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, increasing storm frequency and magnitude, and rising seas (Mote et al. 2014; Pierce et al. 2018). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7^{o}C (1.8-6.7^{o}F) by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011, Reeder et al. 2013).

Moreover, as atmospheric carbon emissions increase, more carbon is absorbed by the oceans, changing the pH of the water. Acidification also impacts sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012, Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 11-38 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011, Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick 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, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011, Reeder et al. 2013).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

While in the long run climate change is expected to have a negative impact on listed fish populations, given the short duration of the proposed research activities, climate change is unlikely to have an appreciable effect on any listed fish in that time frame.

2.2.1 Status of the Species

For Pacific salmon and steelhead, 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. We apply the same criteria for other species as well (but in those instance, they are not referred to as “salmonid” population criteria). When any animal population or species has sufficient spatial structure, diversity, abundance, and productivity, it will generally be able to maintain its capacity to adapt to various environmental conditions and 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 extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

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. Information on the status and distribution of all the species considered here can be found in a number of documents, but the most pertinent are the status review updates and recovery plans listed in Table 2 and the specific species sections that follow. These documents and other relevant information may be found on the NOAA Fisheries West Coast Region website; the discussions they contain are summarized in the tables below. 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.

Table 2. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013a	NWFSC 2015	This ESU comprises 32 independent populations. Twenty-seven populations are at very high risk, 2 populations are at high risk, one population is at moderate risk, and 2 populations are at very low risk Overall, there was little change since the last status review in the biological status of this ESU, although there are some positive trends. Increases in abundance were noted in about 70% of the fall-run populations and decreases in hatchery contribution were noted for several populations. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.	• Reduced access to spawning and rearing habitat • Hatchery-related effects • Harvest-related effects on fall Chinook salmon • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Contaminants
California Coastal Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2016a	Williams et al. 2016	This ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook salmon, and an unknown number of dependent populations. Based on the data available, eight of the 16 populations were classified as data deficient, one population was classified as being at a Moderate/High risk of extirpation, and six populations were classified as being at a High risk of extirpation. 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.	• Logging and road construction altering substrate composition, increasing sediment load, and reducing riparian cover • Estuarine alteration resulting in lost complexity and habitat from draining and diking • Dams and barriers diminishing downstream habitats through altered flow regimes and gravel recruitment • Climate change • Urbanization and agriculture degrading water quality from urban pollution and agricultural runoff • Gravel mining creating barriers to migration, stranding of adults, and promoting spawning in poor locations • Alien species (i.e. Sacramento Pikeminnow) • Small hatchery production without monitoring the effects of hatchery releases on wild spawners

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Central Valley spring-run Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2014a	Williams et al. 2016	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Dams block access to 90 percent of historic spawning and summer holding areas along with altering river flow regimes and temperatures. • Diversions • Urbanization and rural development • Logging • Grazing • Agriculture • Mining – historic hydraulic mining from the California Gold Rush era. • Estuarine modified and degraded, thus reducing developmental opportunities for juvenile salmon • Fisheries • Hatcheries • 'Natural' factors (e.g. ocean conditions)
Sacramento River winter-run Chinook salmon	Endangered 01/04/1994 (59 FR 440)	NMFS 2014a	Williams et al. 2016	This ESU comprises four populations, all blocked from their historic spawning grounds. The overall ESU viability has declined since the 2010 viability assessment, with the single spawning population on the mainstem Sacramento River. Poor early life stage survival during the most recent consecutive drought years of 2012-2015, coupled with poor ocean conditions and hatchery production practices may further impact survival-to-adulthood and risk of extinction. ESU viability can be improved by re-establishing winter-run Chinook salmon in their historical spawning and rearing habitat. Projects to reintroduce winter-run Chinook salmon into Battle Creek and upstream from Shasta Reservoir are in the planning phases, and if successful, would significantly benefit the ESU.	• Dams - Shasta and Keswick dams block all historic spawning and rearing habitat for this ESU. • Diversions - routing of upper Sacramento River-origin water through agricultural fields and create false attraction cues • Urbanization and rural development • Logging • Grazing • Agriculture - impaired water quality from pesticide and herbicide reduces habitat quality • Mining – historic hydraulic mining from the California Gold Rush era. • Estuarine modified and degraded, thus reducing developmental opportunities for juvenile salmon

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
					Fisheries – maximum allowable impact rates range from 12.9% to 19.0% (2012-2015). • Hatcheries • 'Natural' factors (e.g. ocean conditions)
Central California Coast coho salmon	Endangered 04/02/2012 (77 FR 19552) 06/28/2005 (70 FR 37160) Threatened 10/31/1996 (61 FR 56138)	NMFS 2012	Williams et al. 2016	This ESU comprises approximately 76 populations which are mostly dependent populations. Historically, the ESU had 11 functionally independent populations and one potentially independent population organized into four stratum. Most independent populations remain at critically low levels, with those in the southern Santa Cruz Mountains strata likely extirpated. Data suggests some populations show a slight positive trend in annual escapement, but the improvement is not statistically significant. Overall, all 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 survival and recovery.	• Logging • Agriculture • Mining • Urbanization • Stream modifications - including 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 • Dams • Wetland loss • Water withdrawals (including unscreened diversions for irrigation)
Southern Oregon/ Northern California Coast coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2014b	Williams et al. 2015	This ESU comprises 31 independent, 9 independent, and 5 ephemeral populations all grouped into 7 diversity strata. Of the 31 independent populations, 24 are at high risk of extinction and 6 are at moderate risk of extinction. The extinction risk of an ESU depends upon the extinction risk of its constituent independent populations; because the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable	• Lack of floodplain and channel structure • Impaired water quality • Altered hydrologic function • Impaired estuary/mainstem function • Degraded riparian forest conditions • Altered sediment supply • Increased disease/predation/competition • Barriers to migration • Fishery-related effects • Hatchery-related effects
Northern California steelhead	Threatened 6/7/2000 (65 FR 36074)	NMFS 2016a	NMFS 2016b	This DPS historically comprised 42 independent populations of winter-run steelhead (19 functionally independent and 23 potentially independent), and up to 10 independent populations (all functionally independent) of summer-run steelhead, with more than 65	• Dams and other barriers to migration • Logging • Agriculture • Ranching • Fishery-related effects • Hatchery-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				dependent populations of winter-run steelhead in small coastal watersheds, and Eel river tributaries. Many populations are considered to be extant. Significant gaps in information exist for the Lower Interior and North Mountain Interior diversity strata. All winter-run populations are currently well below viability targets, with most at 5-13% of these goals. Mixed population trends arise depending on time series length; thus, there is no strong evidence to indicate conditions for winter-run populations have worsened appreciably since the last status review. Summer-run populations are of concern. While one run is near the viability target, others are very small or there is a lack of data. Overall, available information for winter- and summer-run populations do not suggest an appreciable increase or decrease in extinction risk since the last status review.	
California Central Valley steelhead	Threatened 3/19/1998 (63 FR 13347)	NMFS 2014a	Williams et al. 2016	Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries. The status of this DPS appears to have changed little since the 2011 status review stating the DPS was in danger of extinction. There is still a paucity of data on the status of wild populations. There are some encouraging signs of increased returns over the last few years. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates natural production of steelhead throughout the Central Valley remains at very low levels. Despite a positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.	• Major dams • Water diversions • Barriers • Levees and bank protection • Dredging and sediment disposal • Mining • Contaminants • Alien species • Fishery-related effects • Hatchery-related effects
Central California Coast steelhead	Threatened 8/18/1997	NMFS 2016a	NMFS 2016c	Both adult and juvenile abundance data are limited for this DPS. It was historically comprised	• Dams and other barriers to migration • Stream habitat degradation

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
	(62 FR 43937)			of 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead. Most of the coastal populations are assumed to be extant with other populations (Coastal San Francisco Bay and Interior San Francisco Bay) likely at high risk of extirpation. 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.	• Estuarine habitat degradation • Hatchery-related effects
South-Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2013b	NMFS 2016d	Currently, nearly half of this DPS reside in the Carmel River. Most other streams and rivers have small populations that can be stochastically driven to extirpation. The ability to fully assess the status of individual populations and the DPS as whole has been limited. There is little new evidence to indicate that the status of the S-CCC Steelhead DPS has changed appreciably since the last status review, though the Carmel River runs have shown a long term decline. Threats to the DPS identified during initial listing have remained largely unchanged, though some fish passage barriers have been removed. Threats to this DPS are likely to exacerbate the factors affecting the continued existence of the DPS. S-CCC steelhead recovery will require reducing threats, maintaining interconnected populations across their native range, and preserving the diversity of life history strategies.	• Hydrological modifications- dams, surface water diversions, groundwater extraction • Agricultural and urban development, roads, other passage barriers • Flood control, levees, channelization • Alien species • Estuarine habitat loss • Marine environment threats • Natural environmental variability • Pesticide contaminants
Southern DPS of green sturgeon	Threatened 04/07/2006 (71 FR 17757)	NMFS 2018	NMFS 2015	The Sacramento River contains the only known green sturgeon spawning population in this DPS. The current estimate of spawning adult abundance is between 824-1,872 individuals. Telemetry data and genetic analyses suggest that Southern DPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey	• Reduction of its spawning area to single known population • Lack of water quantity • Poor water quality • Poaching

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				Bay, California and, within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays. Within the nearshore marine environment, tagging and fisheries data indicate that Northern and Southern DPS green sturgeon prefer marine waters of less than a depth of 110 meters.	
Southern resident killer whale	Endangered 11/18/2005 (70 FR 69903)	NMFS 2008	Ford 2013	The Southern Resident killer whale DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. The estimated effective size of the population (based on the number of breeding individuals under ideal genetic conditions) is very small — <30 whales, or about 1/3 of the current population size. The small effective population size, the absence of gene flow from other populations, and documented breeding within pods may elevate the risk from inbreeding and other issues associated with genetic deterioration. As of July 1, 2013, there were 26 whales in J pod, 19 whales in K pod and 37 whales in L pod, for a total of 82 whales. Estimates for the historical abundance of Southern Resident killer whales range from 140 whales (based on public display removals to 400 whales, as used in population viability analysis scenarios.	• Quantity and quality of prey • Exposure to toxic chemicals • Disturbance from sound and vessels • Risks from oil spills

Species-specific status information is discussed in more detail below. The natural abundance numbers presented should be viewed with caution, however, as they only address 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 do not include 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.).

2.2.1.1 Lower Columbia River Chinook Salmon

Listed Hatchery Juvenile Releases – This ESU includes fifteen ESA-listed artificial propagation programs (79 FR 20802). From 2014-2018, the geometric means for the releases from these hatcheries are 32,854,727 LHAC and 1,070,903 LHIA LCR Chinook salmon smolts (Zabel 2014, 2015, 2017a, 2017b, 2018).

Adult spawners and expected outmigration – The average abundance for LCR Chinook salmon populations is 68,061 adult spawners (29,469 natural-origin and 38,594 hatchery-origin spawners; Table 3.

Table 3. Average abundance estimates for LCR Chinook salmon natural- and hatchery-origin spawners (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page).

Population Name	Years	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin
Coastal Stratum – Fall run				
Youngs Bay	2012-2014	233	5,606	96.01%
Grays/Chinook	2010-2014	100	357	78.12%
Big Creek	2012-2014	32	1,510	97.92%
Elochoman/Skamokowa	2010-2014	116	580	83.33%
Clatskanie	2012-2014	98	3,193	97.02%
Mill/Abernathy/Germany	2010-2014	92	805	89.74%
Cascade Stratum – Fall run				
Lower Cowlitz	2010-2013	723	196	21.33%
Upper Cowlitz	2010-2013	2,873	961	25.07%
Toutle	2010-2014	3,305	5,400	62.03%
Coweeman	2010-2014	385	963	71.44%
Kalama	2010-2014	803	8,892	91.72%
Lewis	2010-2014	2,178	943	30.21%
Washougal	2010-2014	192	116	37.66%
Clackamas	2012-2014	1,272	2,955	69.91%
Sandy	2012-2014	1,207	320	20.96%
Columbia Gorge Stratum – Fall run				
Lower Gorge	2003-2007	146	-	-

Population Name	Years	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin
Upper Gorge	2010-2012	200	327	62.05%
White Salmon	2010-2014	829	246	22.88%
Cascade Stratum – Late fall run				
North Fork Lewis	2010-2014	12,330	0	0.00%
Cascade Stratum – Spring run				
Upper Cowlitz/Cispus	2010-2014	279	3,614	92.83%
Kalama	2011-2014	115	-	-
North Fork Lewis	2010-2014	217	0	0.00%
Sandy	2010-2014	1,731	1,470	45.92%
Gorge Stratum – Spring run				
White Salmon	2013-2014	13	140	91.50%
ESU Average		**29,469**	**38,594**	**56.70%**

To estimate abundance of juvenile LCR Chinook salmon, we calculate the geometric mean for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018). For 2014-2018, the estimated outmigration for juvenile natural-origin LCR Chinook salmon is 11,856,775 juvenile salmon.

2.2.1.2 California Coastal Chinook Salmon

Listed Hatchery Juvenile Releases – There are no listed hatchery programs for this ESU.

Adult spawners and expected outmigration – Although there is limited population-level estimates of abundance for CC Chinook salmon populations, Table 3 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 salmon ESU is 7,034 adults (Table 4).

Table 4. Average abundance for CC Chinook salmon natural-origin spawners (Metheny and Duffy 2014, PFMC 2013, Ricker et al. 2014, Mattole Salmon Group 2011, Potter Valley Irrigation District - Van Arsdale Fish Counts webpage, Sonoma Water - Chinook Salmon in the Russian River webpage).

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

Population	Years	Spawners	Expected Number of Outmigrants[ab]
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
ESU Average		**7,034**	**1,278,078**

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

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 salmon 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.

2.2.1.3 Central Valley Spring-run Chinook Salmon

Listed Hatchery Juvenile Releases – The Feather River Hatchery is the only ESA-listed hatchery for the CVSR Chinook salmon (79 FR 20802). From 1999-2009, the hatchery has released, on average, 2,169,329 CVSR Chinook salmon smolts (all adipose-clipped) (California HSRG 2012).

Adult spawners and expected outmigration – The average abundance[2] (2013-2017) for CVSR Chinook salmon populations is 6,000 adult spawners (3,727 natural-origin and 2,273 hatchery-origin spawners; Table 5. Historic spawning habitat on the Feather River is blocked by Oroville Dam, so all CVS Chinook salmon are returned to the hatchery (Williams et al. 2016; CDFW 2018).

Table 5. Average abundance estimates for CVSR Chinook salmon natural- and hatchery-origin spawners 2013-2017 (CDFW 2018).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
Southern Cascades Stratum				
Battle Creek	191	0	0%	39,761
Mill Creek	302	0	0%	62,807
Deer Creek	409	0	0%	85,049

[2] Average abundance calculations are the geometric mean. The geometric mean of a collection of positive data is defined as the nth root of the product of all the members of the data set, where n is the number of members. Salmonid abundance data tend to be skewed by the presence of outliers (observations considerably higher or lower than most of the data). For skewed data, the geometric mean is a more stable statistic than the arithmetic mean.

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
Butte Creek	2,750	0	0%	572,056
Big Chico Creek	0	0	0%	0
Antelope Creek	3	0	0%	598
Coastal Range Stratum				
Clear Creek	73	0	0%	15,143
Cottonwood / Beegum creeks	0.3	0	0%	60
Northern Sierra Stratum				
Feather River	0	2,273	100%	-
ESU Average	**3,727**	**2,273**	**37.9%**	**775,474**

[a] Geometric mean (2013-2017) of post-fishery spawners.

[b] Expected number of outmigrants=Total spawners*50% proportion of females*4,131 eggs per female*10% survival rate from egg to outmigrant.

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 1,862 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 775 thousand natural outmigrants annually.

2.2.1.4 Sacramento River Winter-run Chinook Salmon

Listed Hatchery Juvenile Releases – Only one artificial propagation program is considered to be part of the SacR winter-run Chinook salmon ESU (79 FR 20802) – the Livingston Stone National Fish Hatchery (NFH). Annual releases from the hatchery are limited to 200,000 juvenile SacR winter-run Chinook salmon (all adipose-clipped) (NMFS consultation number WCR-2016-4012, Section 10(a)(1)(A) permit #16477).

Adult spawners and expected outmigration – The average abundance (2013-2017) for SacR winter-run Chinook salmon populations is 2,442 adult spawners (2,232 natural-origin and 210 hatchery-origin spawners; Table 6).

Table 6. Average abundance estimates for SacR winter-run Chinook salmon natural- and hatchery-origin spawners 2013-2017 (CDFW 2018).

Year	Natural-origin Spawners	Hatchery-origin Spawners	Percent Hatchery Origin	Expected Number of Outmigrants[a]
2013	5,920	164	2.7%	486,720
2014	2,627	388	12.9%	241,200
2015	3,182	258	7.5%	275,200
2016	1,409	137	8.9%	123,680
2017	795	180	18.5%	78,000
ESU Average[d]	**2,232**	**210**	**8.6%**	**195,354**

[a] Geometric mean (2013-2017) of post-fishery spawners.

[b] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant.

Juvenile SacR winter-run Chinook salmon 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 – 977 females), the ESU is estimated to produce approximately 1.95 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 195,354 natural outmigrants annually.

2.2.1.5 Central California Coast Coho Salmon

Listed Hatchery Juvenile Releases – The CCC coho salmon ESU includes three artificial propagation programs (79 FR 20802). Recent hatchery releases for CCC coho salmon have averaged 165,880 LHAC juveniles (Table 7).

Table 7. Average juvenile CCC coho salmon hatchery releases.

Artificial propagation program	Watershed	Years	Clipped Adipose Fin
Don Clausen Fish Hatchery Captive Broodstock Program[a]	Russian River tributaries	2014-2018	132,680
Scott Creek/King Fisher Flats Conservation Program[b]	Gazos and San Vicente creeks	2018	12,000
Scott Creek Captive Broodstock Program[c]	Scott Creek	2013-2017	21,200
Average Annual Release Number			**165,880**

[a] Source - Sea Grant California - Hatchery Releases webpage
[b] Source - Monterey Bay Salmon & Trout Project webpage
[c] Source - NOAA Fisheries - Species in the Spotlight Action Plan Implementation Highlights webpage

Adult spawners and expected outmigration – The current average run size for the CCC coho salmon ESU is 2,259 fish (1,932 natural-origin; 327 hatchery produced) (Table 8).

Table 8. Geometric mean abundances of CCC coho salmon spawner escapements by population (Williams et al. 2016). Populations in bold font are independent populations.

Stratum	Population	Spawners		Expected Number of Outmigrants[b]
		Natural-origin	Hatchery-origin[a]	
Lost Coast – Navarro Point	**Ten Mile River**	69	-	4,830
	Usal Creek	4	-	280
	Noyo River	455	-	31,850
	Pudding Creek	184	-	12,880
	Caspar Creek	40	-	2,800
	Big River	183	-	12,810
	Little River	30		2,100

Stratum	Population	Spawners		Expected Number of Outmigrants[b]
		Natural-origin	Hatchery-origin[a]	
	Albion River	21	-	1,470
	Big Salmon Creek	3		210
Navarro Point – Gualala Point	**Navarro River**	102	-	7,140
	Greenwood Creek	3		210
	Garcia River	18	-	1,260
	Gualala River	-	-	-
Coastal	**Russian River**	364[c]	323	48,090
	Salmon Creek	-	-	-
	Walker Creek		-	-
	Lagunitas Creek	408	-	28,560
	Pine Gulch	2		140
	Redwood Creek	23	-	1,610
Santa Cruz Mountains	**Pescadero Creek**	1	-	70
	San Lorenzo River	1	-	70
	Waddell Creek	1	-	70
	Scott Creek	18	4	1,540
	San Vicente Creek	2	-	140
	Soquel Creek	-	-	-
ESU Total		**1,932**	**327**	**158,130**

[a] J. Jahn, pers. comm., July 2, 2013

[b] Expected number of outmigrants=Total spawners*50% proportion of females*2,000 eggs per female*7% survival rate from egg to outmigrant

[d] Arithmetic mean used due to unavailability of geometric mean

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 1,129 females returning (50 percent of the run, including the Russian River hatchery returns which are allowed to spawn in the wild) to this ESU, one may expect approximately 2.2 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can estimate that roughly 158,130 juvenile coho salmon are produced annually by the Central California Coast ESU.

2.2.1.6 Southern Oregon/Northern California Coast Coho Salmon

Listed Hatchery Juvenile Releases – Three artificial propagation programs were listed as part of the ESU (79 FR 20802). Hatchery releases from these hatcheries average 200,000 LHAC and 575,000 LHIA SONCC coho salmon juveniles annually (ODFW 2011, CHSRG 2012).

Adult spawners and expected outmigration – The average abundance for SONCC coho salmon populations is 19,990 adult spawners (9,056 natural-origin and 10,934 hatchery-origin spawners; Table 9).

Table 9. Estimates of the natural-origin and hatchery-produced adult coho salmon returning to the Rogue, Trinity, and Klamath rivers (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project, Kier et al 2015, CDFW 2012).

YEAR	Rogue River		Trinity River		Klamath River		
	Hatchery	Natural	Hatchery	Natural	Shasta River[a]	Scott River[a]	Salmon River
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 2014b).

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 28.8 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we approximate that this ESU produces about 2,013,593 juvenile SONCC coho salmon outmigrants annually.

2.2.1.7 Northern California 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 (Table 10).

Table 10. Historical NC Steelhead Independent Populations (NMFS 2011).

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

Population Groups	Run	Populations
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 11). 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, annual dive surveys have occurred since 1981. Williams et al. (2011) stated at the time the 16-year trend was positive (p = 0.029); however, the critically low abundance overshadowed the trend. For the Upper Eel River, abundance data are 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). The most recent status review found that for many winter-run populations, while long-term trends have been negative run sizes of natural-origin steelhead have stabilized or are increasing. Summer-run populations continue to be of significant concern, and overall available data do not suggest an appreciable change in extinction risk since the 2011 status review despite the fact that most populations remain below viability targets (NMFS 2016e).

Table 11. 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 available surveys, we estimate that the NC steelhead DPS has an annual abundance of 7,221 adults (Table 12).

Table 12. 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 Mountain-Interior	**Eel River**	**Winter**	2011-2015	389	44,249
	South Fork Eel River	**Winter**	2011-2014	574	65,293
	Van Duzen River	**Summer**	2011-2015	115	13,081
	Middle Fork Eel River	**Summer**	2010-2014	796	90,545
North-Central Coastal	**Big River**	**Winter**	2010-2014	465	52,894
	Caspar Creek	**Winter**	2010-2014	31	3,526
	Cottoneva Creek	**Winter**	2010, 2012, 2014	83	9,441
	Hare Creek	**Winter**	2010-2014	2	228
	Juan Creek	**Winter**	2012	39	4,436
	Noyo River	**Winter**	2010-2014	442	50,278
	SF Noyo River	**Winter**	2010-2014	79	8,986
	Pudding Creek	**Winter**	2010-2014	34	3,868
	Ten Mile River	**Winter**	2010-2014	382	43,453
	Usal Creek	**Winter**	2010-2013	54	6,143
	Wages Creek	**Winter**	2010, 2011, 2014	55	6,256
Central Coastal	**Albion River**	**Winter**	2010-2014	45	5,119
	Big Salmon Creek	**Winter**	2012-2013	84	9,555

Stratum	Waterbody	Run	Years	Abundance	Expected Number of Outmigrants[a]
	Brush Creek	**Winter**	2010-2014	6	683
	Garcia River	**Winter**	2010-2014	340	38,675
	Gualala River	**Winter**	2006-2010	1,066	121,258
	Navarro River	**Winter**	2010-2014	332	37,765
	North Fork Navarro River	**Winter**	2013-2014	342	38,903
Total				**7,221**	**821,389**

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

Both adult and juvenile abundance data are 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 12). 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 – 3,610 females), 12.6 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 821,389 natural outmigrants annually. There are not currently hatchery NC steelhead included in this DPS.

2.2.1.8 California Central Valley Steelhead

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 until recently, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and initial results of an adult escapement monitoring plan should be available by the time of the next status review.

Table 13. 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	2008-2009	27	0	3,071
Clear Creek	2011-2015	463	0	52,666
Cow Creek	2008-2009	2	0	228
Feather River	2011-2015	41	1,092	128,879
Mill Creek	2010-2015	166	0	18,883
Mokelumne River	2006-2010	110	133	27,641
Total		**1,686**	**3,856**	**630,403**

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

[b] Based upon number of natural-origin spawners

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 2011). Since 2003, fish returning to the Coleman NFH have been identified as wild (adipose fin intact) or hatchery produced (adipose-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 are 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 13). 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 hatchery- and natural-origin spawners – 2,771 females), 9.7 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 630,403 naturally produced outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million listed hatchery juvenile CCV steelhead each year (Table 14).

Table 14. 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**

2.2.1.9 Central California Coast Steelhead

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 15).

Table 15. Historical CCC Steelhead Populations (NMFS 2011).

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 River, 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

Table 16. 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**

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.

Data for both adult and juvenile abundance are 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 17). 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. In addition, hatchery managers could produce 648,841 listed hatchery juvenile CCC steelhead each year (Table 16). With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 248,771 natural outmigrants annually (Table 17).

Table 17. Geometric Mean Abundances of CCC Steelhead Spawners Escapements by Population (Ettlinger et al. 2012, Jankovitz 2013, Source: http://www.marinwater.org/DocumentCenter/View/200/Walker-Creek-Salmon-Monitoring-Program-Reports-and-References-March-2010?bidId=, Natural abundance: Manning and Martini-Lamb (ed.) 2012; Hatchery abundance source: http://www.scwa.ca.gov/files/docs/projects/rrifr/Final_BO_Report_2011_2012.pdf, Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoUpercent3D&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]**
Northern Coastal	Austin Creek	2010-2012	63	-	7,166
	Lagunitas Creek	2009-2013	71	-	8,076
	Pine Gulch Creek	2010-2014	37		4,209
	Redwood Creek	2010-2014	18		2,048
	Walker Creek	2007-2010	29	-	3,299
Interior	Dry Creek	2011-2012	33	-	3,754
	Russian River	2008-2012	230	3,451	26,163
Santa Cruz Mountains	Aptos Creek	2007-2011	249	-	28,324
	Pescadero	2013-2015	361	-	41,064
	Gazos Creek	2013-2015	30	-	3,413
	Waddell Creek	2013-2014	73	-	8,304
	San Gregorio Creek	2014-2015	135	-	15,356
	San Lorenzo River	2013-2015	423	319	48,116
	San Pedro Creek	2013	38		4,323
	San Vicente Creek	2013-2015	35		3,981
	Scott Creek	2011-2015	120	96	13,650
	Soquel Creek	2007-2011	230	-	26,163
Central Coastal	Napa River	2009-2012	12	-	1,365
		Totals	**2,187**	**3,866**	**248,771**

[a]Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant
[b]Based upon natural-origin spawner numbers

Good et al. (2005) concluded that due to past declines, threats to genetic integrity, and available abundance data the CCC steelhead DPS was not presently in danger of extinction but was likely to become so in the future. While data indicated that CCC steelhead remain present in the Santa Cruz mountains, reducing overall extinction risk of the DPS, subsequent reviews of DPS viability (Williams et al. 2011, NMFS 2016e) have concluded there was not sufficient information to indicate any change in DPS viability, although they acknowledge high levels of uncertainty surrounding most populations (NMFS 2016e). 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.

2.2.1.10 South-Central California Coast Steelhead

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) (Table 18). 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.

Table 18. Historical S-CCC Steelhead Populations (NMFS 2012).

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

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

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

Both adult and juvenile abundance data are 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 19). Juvenile S-CCC steelhead abundance estimates come from the escapement data. 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 (Table 19).

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 are 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.

2.2.1.11 Southern Green Sturgeon

Green sturgeon are composed of two DPSs 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. Since 2010, Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River for S green sturgeon have been conducted. Annually, green sturgeon adults were monitored with tagged individuals showing a mean spawning periodicity was 3.69 years (Mora et al. 2018). Results from these surveys for S green sturgeon resulted in an estimate of 4,387 juveniles (freshwater stage, less than 60 cm length, and one to three years of age), 11,055 sub-adults (3-20 years and 60-165 cm length), and 2,106 adults (greater than 165 cm in length and older than 20 years) (Table 20; Mora et al. 2018).

Table 20. Six-year geometric mean (2010-2015) abundance estimate of S green sturgeon (Mora et al. 2018).

		95% Confidence Interval	
Lifestage	**Estimate**	**Low**	**High**
Juvenile	4,387	2,595	6,179
Sub-adult	11,055	6,540	15,571
Adult	2,106	1,246	2,966
ESU abundance[a]	**17,548**	**12,614**	**22,482**

2.2.2 Status of the Species' Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-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 most salmon and steelhead, NMFS's critical habitat analytical review teams (CHARTs) ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each ESA-listed species that they support (NMFS 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, 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. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential due to factors such as limited availability, a unique contribution of the population it served, or is serving another important role.

A summary of the status of critical habitats, considered in this opinion, is provided in Table 21, below.

Table 21. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Lower Columbia River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or high potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.
California Coastal Chinook salmon	09/02/2005 70 FR 52488	Critical habitat includes approximately 1,475 miles of stream habitats and 25 square miles of estuary habitats. 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. PBFs include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. Since designation, critical habitat for this species has continued to be. 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 Valley spring-run Chinook salmon	09/02/2005 70 FR 52488	Critical habitat includes approximately 1,373 miles of stream habitats and 427 square miles of estuary habitats 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. PBFs include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. 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	06/16/1993 58 FR 33212	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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
	Modified 03/23/1999 64 FR 14067	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 the CHART team process, thus watersheds have not yet been evaluated for conservation value. Since designation, critical habitat for this species has continued to be degraded. 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	05/05/1999 64 FR 24049	Critical habitat 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 the CHART team process, thus watersheds have not yet been evaluated for conservation value. Since designation, critical habitat for this species has continued to be degraded. 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	05/05/1999 64 FR 24049	Critical habitat includes all areas accessible to any life-stage up to long-standing, natural barriers and adjacent riparian zones. SONCC coho salmon critical habitat within this geographic area has been degraded from historical conditions by ongoing land management activities. Habitat impairments recognized as factors leading to decline of the species that were included in the original listing notice for SONCC coho salmon include: 1) Channel morphology changes; 2) substrate changes; 3) loss of in-stream roughness; 4) loss of estuarine habitat; 5) loss of wetlands; 6) loss/degradation of riparian areas; 7) declines in water quality; 8) altered stream flows; 9) fish passage impediments; and 10) elimination of habitat
Northern California steelhead	9/2/2005 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 sites and habitat components which support one or more life stages. 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, have high conservation value ratings. 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	9/2/2005 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. 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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		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	9/2/2005 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 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. For conservation value to the DPS, fourteen watersheds received a low rating, 13 received a medium rating, and 19 received a high rating. Since designation, critical habitat for this species continues to be degraded by several factors listed in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities to improve conditions in some areas and slow the negative trend.
South-Central California Coast steelhead	9/2/2005 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 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. For conservation value to the DPS, six watersheds received a low rating, 11 received a medium rating, and 13 received a rated high. Morro Bay, an estuarine habitat, is used as rearing and migratory habitat for spawning and rearing steelhead. 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. Since designation, critical habitat for this species continues to be degraded by several factors listed in the status section Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities to improve conditions in some areas and slow the negative trend.
Southern DPS of green sturgeon	10/09/2009 74 FR 52300	Critical habitat has been designated in coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; tidally influenced areas of the Columbia River estuary from the mouth upstream to river mile 46; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor), including, but not limited to, areas upstream to the head of tide in various streams that drain into the bays, as listed in Table 1 in USDC (2009). The CHART identified several activities that threaten the PBFs in coastal bays and estuaries and necessitate the need for special management considerations or protection. The application of pesticides is likely to adversely affect prey resources and water quality within the bays and estuaries, as well as the growth and reproductive health of Southern DPS green sturgeon through bioaccumulation. Other activities of concern include those that disturb bottom substrates, adversely affect prey resources, or degrade water quality through re-suspension of contaminated sediments. Of particular concern are activities that affect prey resources. Prey resources are affected by: commercial

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		shipping and activities generating point source pollution and non-point source pollution that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom (but result in beneficial or adverse effects on prey resources for green sturgeon).
Southern resident killer whale	11/29/2006 71 FR 69054	Critical habitat consists of three specific marine areas of inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PBFs, or physical or biological features, essential for the conservation of Southern Residents: 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 Water quality in Puget Sound, in general, is degraded. Some pollutants in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features In regards to passage, human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whales' passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior. Reduced prey abundance, particularly Chinook salmon, is also a concern for critical habitat.

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). For the purposes of this opinion, the action area includes all river reaches accessible to listed Chinook salmon, coho salmon, and steelhead in all sub-basins of California. Additionally, the action area includes all marine waters off the West Coast of the continuous United States, including nearshore waters from the California/Oregon border south to the Mexican border with the United States, accessible to listed Chinook salmon, coho salmon, steelhead, and green sturgeon.

Where it is possible to narrow the range of the research, the effects analysis would take that limited geographic scope into account when determining the proposed actions' impacts on the species and their critical habitat (see permit summaries below for the instances in which this would be applicable). Still, the action area is generally spread out over much of California. It is also discontinuous. That is, there are large areas in between the various actions' locations where listed salmonids and sturgeon 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 those effects are described in the Not Likely to Adversely Affect section (2.11).

In most 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. Many of the proposed research activities would take place in designated critical habitat. More detailed habitat information (i.e., migration barriers, physical and biological habitat features, and special management considerations) for species considered in this opinion may be found in the Federal Register notices designating critical habitat (Table 21).

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 and in the species' status sections) have had on the various listed species' survival and recovery. In many cases, the action area under consideration covers individual animals that could come from anywhere in the various listed species' entire ranges (see Sections 1.3 and 2.3). As a result, the effects of these past activities on the species themselves (that is, effects on abundance, productivity, etc.) cannot be tied to any particular population and are therefore displayed individually in the species status section summaries above (see Section 2.2).

Thus, for some of the work being contemplated here, the impacts that previous Federal, state, and private activities in the action area have had on the species are indistinguishable from those effects summarized below and in the previous section on the species' rangewide status. The same is true with respect to the species' habitat: for some of the work contemplated, the environmental baseline is the result of these activities' rangewide effects on the PBFs that are essential to the conservation of the species. However, as noted previously, some of the proposed work has a more limited geographic scope. If the work would not take place in marine or mainstem areas or would not be randomly distributed throughout the majority of a given species' range, then the action area can be narrowed for a more specific analysis—and in those instances, the relevant local status information will be taken into account for both species and critical habitat.

Analysis at the ESU/DPS level will be performed for all permits listed in Table 1. The permits for which population-level analysis will be performed are:

- 14808-4M
- 15169-2R
- 16506-3R
- 22270
- 22700
- 16318-3M

2.4.1 Summary for all Listed Species

2.4.1.1 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). Very generally, these include harvest and hatchery practices and habitat degradation and curtailment caused by human development and resource extraction. NMFS' decisions to list the species identified a variety of factors that were limiting their recovery. None of these documents identifies scientific research as either a cause for decline or a factor preventing their recovery. See tables 2 and 19 for summaries of the major factors limiting recovery of the listed species and how various factors have degraded PBFs and harmed listed species considered in this opinion.

Thus, as a general matter, all the species considered in this opinion have at least some biological requirements that are not being met in the action area. The listed species are still experiencing the impact of a variety of past and ongoing Federal, state, and private activities in the action area and that impact is expressed in the limiting factors described above and in the species status sections—all of which, in combination, are currently keeping the species from recovering and actively preventing them from having all their biological requirement met in the action area.

For detailed information on how various factors have degraded PBFs and harmed listed species, please see any of the following: Busby et al. 1996, Good et al. 2005, Ford 2011, NMFS 2016e, NWFSC 2016, and section 2.2.2.

Research Effects

Although not 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—whether intentionally or not. For the year 2019, NMFS has issued numerous research section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species, along with the state scientific research programs under ESA section 4(d) and tribal 4(d) research. Table 22 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A).

Table 22. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2019.

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Adult	Natural	371	6	1.26	0.02
		LHIA	12	0	0.36 [b]	0.01 [b]

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Lower Columbia River Chinook salmon		LHAC	128	2		
	Juvenile	Natural	819,725	11,369	6.91	0.10
		LHIA	444	53	0.04	0.00
		LHAC	62,575	1,466	0.19	
California Coastal Chinook salmon	Adult	Natural	1,025	32	14.57	0.45
	Juvenile	Natural	307,087	3,934	24.03	0.31
Central Valley spring-run Chinook salmon	Adult	Natural	697	22	18.70	0.59
		LHAC	536	52	23.58	2.29
	Juvenile	Natural	873,546	16,832	112.65	2.17
		LHAC	19,030	3,043	0.88	0.14
Sacramento River winter-run Chinook salmon	Adult	Natural	273	11	130.00	5.24
		LHAC	197	53	8.83	2.37
	Juvenile	Natural	175,525	5,077	89.85	2.60
		LHAC	12,546	1,491	6.27	0.75
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	1,575	25	17.37	0.28
		LHIA	1,577	17	19.84 [b]	0.25 [b]
		LHAC	592	10		
	Juvenile	Natural	190,139	2,699	9.44	0.13
		LHIA	11,151	381	1.94	0.07
		LHAC	1,456	42	0.73	0.02
Central California Coast coho salmon	Adult	Natural	2,238	34	115.84	1.76
		LHIA	1,497	31	457.80	9.48
	Juvenile	Natural	168,368	3,235	106.47	2.05
		LHIA	67,166	1,417	40.49	0.85
		LHAC	25,390	762	-	-
Northern California Steelhead	Adult	Natural	2,757	18	38.18	0.25
	Juvenile	Natural	254,416	4,102	30.97	0.50
California Central Valley Steelhead	Adult	Natural	3,303	84	195.91	4.98
		LHAC	2,009	96	52.10	2.49
	Juvenile	Natural	62,652	2,003	9.94	0.32

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		LHAC	24,681	1,413	1.54	0.09
Central California Coast Steelhead	Adult	Natural	1,553	32	71.01	1.46
		LHAC	482	17	12.47	0.44
	Spawned Adult/ Carcass	Natural	265	4	-	-
		LHAC	100	2		
	Juvenile	Natural	189,845	4,622	76.31	1.86
		LHIA	6,200	124	-	-
		LHAC	11,681	319	1.80	0.05
South-Central California Coast Steelhead	Adult	Natural	547	6	78.71	0.86
	Spawned Adult/ Carcass	Natural	20	1	-	-
	Juvenile	Natural	49,124	1,242	62.14	1.57
Southern DPS green sturgeon	Adult	Natural	176	5	4.01	0.11
	Subadult	Natural	40	2	0.36	0.02
	Juvenile	Natural	1,611	111	76.50	5.27
	Larvae	Natural	11,015	1,015	-	-
	Egg	Natural	1,350	1,350		

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.

Actual take levels associated with these activities are almost certain to be substantially lower than the permitted levels. There are two primary reasons for this. First, most researchers do not handle the full number of juveniles or adults they are allowed. Based on our take tracking system, over the past five years (2014-2018) all section 10(a)(1)(A) permits active in California for ESA-listed steelhead and salmon resulted in only 8.8% of the requested handling (i.e., non-observation) take (489,389 of 5,575,092) and 3.6% of the requested mortalities (6,854 of 192,328) occurring. 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, and in some cases many fewer.

An additional assumption that makes it likely the actual take associated with these activities will have less impact than take quantities analyzed in this opinion is that juveniles taken are assumed to be of a single outmigrating year class. Many of the fish that may be affected will be in the smolt stage, but others would not be. These younger life stages, described simply as "juveniles," may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals (perhaps as much as an order of magnitude more) than would actually survive to reach the smolt stage.

Therefore, the estimates of percentages of ESUs/DPSs taken were derived by (a) conservatively estimating the actual number of individual fish taken or killed, (b) overestimating the number of fish likely to be killed unintentionally, and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of salmonids the research is likely to kill are undoubtedly smaller than the figures stated here and in Sections 2.5 and 2.7.

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 research activities are described in the following sections. In general, the permitted activities would be (1) electrofishing, (2) capturing fish with angling equipment, traps, and nets of various types, (3) collecting biological samples from live fish, and (4) collecting 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. Some fish collection activities involve bottom trawls in marine or estuarine environments which may temporarily disturb substrate, displace benthic invertebrate prey, and increase turbidity just above the water surface. However, such trawl actions affect small spatial areas and are brief in duration, so these effects are expected to be ephemeral and attenuate rapidly. Therefore none of the activities analyzed in this Opinion will measurably affect any habitat PBF function or value as described in Section 2.2.2.

2.5.2 Effects on the Species

As discussed above, the proposed research activities will have no measurable effects on the habitat of listed salmonids. The actions are therefore not likely to measurably affect any of the listed species by reducing their habitat's ability 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, handling, and intentionally euthanizing fish. Harassment caused by capturing, handling, tagging or sampling, and releasing fish generally leads to stress and other sub-lethal effects, although a small number of fish captured will sometimes die from such treatment.

The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all permits analyzed in this Opinion. These activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and 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. These measures are described in Section 1.3 of this opinion. They are incorporated (where relevant) into every permit as part of the conditions to which a researcher must adhere.

Observation

For some parts of the proposed studies, listed fish would be observed but not captured (e.g., by snorkel surveys or from the banks). Observation without handling 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 (included in state fisheries agency submittals), 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.

Capture/handling

Any physical handling or 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 18ºC 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 identified earlier in subsection 1.3 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, which makes them easy to capture. It can cause a suite of effects ranging from disturbing the fish to killing them. The percentage of fish that are unintentionally killed by electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician (Sharber and Carothers 1988, McMichael 1993, Dalbey et al. 1996; Dwyer and White 1997). Research indicates that using continuous direct current (DC) or low-frequency (30 Hz) pulsed DC waveforms produce lower spinal injury rates, particularly for salmonids (Fredenberg 1992, McMichael 1993, Sharber et al. 1994, Snyder 1995).

Most studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). Electrofishing can have severe effects on adult salmonids. Adult salmonids can be injured or killed due to spinal injuries that can result from forced muscle contractions. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study.

Spinal injury rates are substantially lower for juvenile fish than for adults. 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) reported a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin.

When using appropriate electrofishing protocols and equipment settings, shocked fish normally revive quickly. Studies on the long-term effects of electrofishing indicate that even with spinal injuries, salmonids can survive long-term, however, severely injured fish may have stunted growth (Dalbey et al. 1996, Ainslie et al. 1998).

Permit conditions would require that all researchers follow NMFS' electrofishing guidelines (NMFS 2000). The guidelines require that field crews:

- Use electrofishing only when other survey methods are not feasible.
- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.
- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and conduct careful reconnaissance surveys prior to electrofishing at additional sites.
- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.
- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.
- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.

- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

The preceding discussion focused on the effects backpack 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. The environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. As a result, boat electrofishing can have a greater impact on fish. Researchers conducting boat electrofishing must follow NMFS' electrofishing guidelines.

Weirs

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

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

Trawls

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

Angling

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

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

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

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

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

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

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

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

Spearfishing

Spearfishing is a fish harvest strategy which involves "fishing for, attempting to fish for, catching or attempting to catch fish by any person with a spear or a powerhead (see 50 CFR 600.10)". Spear means "a sharp, pointed, or barbed instrument on a shaft" (50 CFR 600.10). Spears can be operated by hand (manually) or shot from a gun or sling. In some coastal environments, underwater spearfishing can alter fish assemblages (Lloret et al. 2008) by selectively targeting large individuals, altering size structure of target species or decreasing fish densities (Basta and Kennedy 2006). Large fish are ecologically important due to food web impacts and reproductive contributions, among other reasons; therefore, selective fishing for large individuals through this gear type could have indirect impacts on fish community assemblages. However, we would not allow spearfishing that would intentionally target adults or juveniles for ESA-listed species, so there would be no such effects on these species.

One advantage of this gear type is its high selectivity and minimal impacts to nontarget species and surrounding habitat compared to other fishing methods. A major disadvantage of the spearfishing method is the inability to catch and release captured individuals. Spears are designed to penetrate fish flesh and therefore can be lethal. The main concern with this technique centers on whether spearfish operators are able to reliably determine species, as releasing the fish post-capture would likely result in mortality, depending on wound severity. As a result, we will only authorize this technique in cases where it can be reliably demonstrated that the persons carrying out the action are sufficiently trained and experienced in fish identification.

Tagging/Marking

Techniques such as Passive Integrated Transponder (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 km), Hockersmith et al. (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically- or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall Chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Conner et al. 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain within 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 within 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 within 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.

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 mm 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% 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.

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.

Sacrifice (Intentionally Killing)

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 they are juveniles, are forever removed from the gene pool and the effect of their deaths is weighed in the context that the effect on their listed unit and, where possible, their local population. 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-spawned adults has the greatest potential to affect the listed species. Because of this, NMFS only very rarely allows pre-spawned adults to be sacrificed, 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. As a general rule, adults are not sacrificed for scientific purposes and no such activity is considered in this opinion.

2.5.3 Species-specific Effects of Each Permit

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids, and green sturgeon. Since there are no measurable habitat effects, the analysis will consist primarily of examining directly measurable impacts of proposed activities on abundance. Abundance effects are themselves relevant to extinction risk, are directly related to productivity effects, and are somewhat but less directly to structure and diversity effects. Examining the magnitude of these effects at the individual and, where possible, population levels is the best way to determine effects at the species level.

The analysis process relies on multiple sources of data. In Section 2.2.1 (Status of the Species), 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. These data come from estimates compiled by our Science Centers for the species status reviews, which are updated every five years. Additional data sources include state agencies (i.e. CDFW, IDFW, ODFW, WDFW), county and local agencies, and educational and non-profit institutions. These sources are vetted for scientific accuracy before their use. For hatchery propagated juvenile salmonids, we use hatchery production goals. Table 23 displays the estimated annual abundance of hatchery-propagated and naturally produced listed fish.

Table 23. Estimated annual abundance of ESA listed fish.

Species	Life Stage	Origin	Abundance
	Adult	Natural	29,469

Species	Life Stage	Origin	Abundance
Lower Columbia River Chinook salmon		LHIA, LHAC[b]	38,594
	Juvenile	Natural	11,856,775
		LHIA	1,070,903
		LHAC	32,854,727
California Coastal Chinook salmon	Adult	Natural	7,034
	Juvenile	Natural	1,278,078
Central Valley spring-run Chinook salmon	Adult	Natural	3,727
		LHAC	2,273
	Juvenile	Natural	775,474
		LHAC	2,169,329
Sacramento River winter-run Chinook salmon	Adult	Natural	210
		LHAC	2,232
	Juvenile	Natural	195,354
		LHAC	200,000
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	9,065
		LHIA, LHAC[b]	10,934
	Juvenile	Natural	2,013,593
		LHIA	575,000
		LHAC	200,000
Central California Coast coho salmon	Adult	Natural	1,932
		LHIA	327
	Juvenile	Natural	158,130
		LHIA	165,880
Northern California Steelhead	Adult	Natural	7,221
	Juvenile	Natural	821,389
	Adult	Natural	1,686

Species	Life Stage	Origin	Abundance
California Central Valley Steelhead		LHAC	3,856
	Juvenile	Natural	630,403
		LHAC	1,600,653
Central California Coast Steelhead	Adult	Natural	2,187
		LHAC	3,866
	Juvenile	Natural	248,771
		LHAC	648,891
South-Central California Coast Steelhead	Adult	Natural	695
	Juvenile	Natural	79,057
Southern DPS green sturgeon	Adult	Natural	4,387
	Subadult	Natural	11,055
	Juvenile	Natural	2,106

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.

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 marine habitat) was such that the take could not reliably be assigned to any population or group of populations. In those cases, the effect of the action is measured in terms of its impact on the relevant species' total abundance by life stage and origin (Natural) and production (Listed Hatchery Adipose Clip (LHAC) and Listed Hatchery Intact Adipose (LHIA)])

Permit 13791-6M

Under permit 13791-6M, the Lodi office of the U.S. Fish and Wildlife Service (FWS) is requesting to modify a 5-year permit that currently allows them to take juvenile CVSR and SRWR Chinook salmon, juvenile CCV steelhead and juvenile green sturgeon in the lower Sacramento and San Joaquin Rivers and SF estuary, CA. The researchers would capture fish with seines (beach and purse), nets (fyke and gill), boat and backpack electroshocking, trawls (midwater and bottom), and with rotary screw traps. The FWS would also observe fish during snorkel and spawning ground surveys. A subset of the captured fish would be anesthetized, measured, weighed, tagged (acoustic or PIT), dye injected (tattoo, photonic) have a tissue sample taken, allowed to recover, and released. In addition, some hatchery-origin CVSR and SRWR Chinook salmon would intentionally be lethally taken, as well as larval sDPS green sturgeon. This modification is requested because the original permit application did not include take of adult salmon, however unintentional encounters with adult fish have occurred. The FWS is requesting take for adult SRWR and CVSR Chinook salmon, CCV steelhead, and sDPS green sturgeon. While the FWS does not target adult fish and would seek to avoid them, encounters with adult fish could take place. as an unintentional result of sampling.

The applicant is requesting the amounts of take shown in Table 24, under the columns ‘Mod Total Take’ and ‘Mod Lethal Take.’ The columns ‘Prior Total Take’ and ‘Prior Lethal Take’ indicate the amounts of take previously authorized by this permit that will continue to be allowed under the modified permit. Only the additional take requested under this permit modification (i.e., take not previously authorized) is analyzed in this Opinion, as reflected in the ‘Percent of ESU/DPS’ columns.

Table 24. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 13791-6M.

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Mod Total Take	Mod Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central Valley spring-run Chinook salmon	Adult	Natural	C/M, T, ST/R	0	0	37	3	0.99	0.08
	Adult	LHAC	C/H/R	0	0	27	3	1.19	0.13
	Juvenile	Natural	C/H/R	4,154	59	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	1,260	12	0	0	-	-
	Juvenile	LHAC	C/H/R	400	4	0	0	-	-
	Juvenile	LHAC	IM	1,682	1,682	0	0	-	-
Sacramento River winter-run Chinook salmon	Adult	Natural	C/M, T, ST/R	0	0	27	2	12.86	0.95
	Adult	LHAC	C/H/R	0	0	21	2	0.94	0.09
	Juvenile	Natural	C/H/R	1,655	37	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	840	6	0	0	-	-
	Juvenile	LHAC	C/H/R	1	0	0	0	-	-
	Juvenile	LHAC	IM	356	356	0	0	-	-
California Central Valley Steelhead	Adult	Natural	C/H/R	0	0	81	8	4.80	0.47
	Adult	LHAC	C/H/R	0	0	81	8	2.10	0.21
	Juvenile	Natural	C/H/R	367	20	0	0	-	-
	Juvenile	LHAC	C/H/R	831	28	0	0	-	-
Southern DPS green sturgeon	Adult	Natural	C/H/R	0	0	16	0	0.36	0.00
	Juvenile	Natural	C/H/R	51	0	0	0	-	-
	Larvae	Natural	IM	10	10	0	0	-	-

C/H/R – Capture/Handle/Release
C/M,T,ST/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
IM – Intentional (Directed) Mortality

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species. These figures are presented in the far-right column of Table 24.

Adult individuals sampled as part of this work are expected to be encountered primarily in bays and deltas, where individuals from multiple populations occur and effects of sampling can't be attributed to individual populations. Therefore, we have analyzed the effects at the ESU/DPS scale. We expect at least 97 percent of fish captured for handling, sampling, and release to survive. As the figures in Table 24, above, demonstrate the research under this modified permit would additionally kill at most 0.95% of the natural-origin adults of the SRWR Chinook salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at much lower rates. We also anticipate that the actual take and mortality associated with this work will be lower than the levels authorized here based on previous years of sampling. Our take tracking system indicates that for prior years of this study, since 2012 only 12.7% of the requested take (10,574 of 83,134 individuals) and 15.6% of the requested mortalities (3,055 of 19,541) has actually occurred, although these rates refer to take of juvenile life stages and not adults.

In addition to the low absolute numbers of adults expected to be encountered or killed as a result of this research, it is important to note that the percent of ESU taken or killed calculated above is almost certainly an overestimate. The abundance data to which take levels are compared are limited, and only capture a portion of the ESU or DPS unit represented, both because complete data are not collected for all populations in these units and sampling often does not capture the entirety of a run or spawning season. Therefore, the actual abundance values for these species are larger than those displayed in Table 23 and Section 2.2.1, and the requested take would impact a smaller proportion of the entire ESU or DPS than what is estimated in Table 24 using available data.

Research associated with Permit modification 13791-6M would therefore have a minor impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing long-term monitoring program generating data regarding the abundance, temporal and spatial distribution, and survival of salmonids and other fishes in the lower Sacramento and San Joaquin Rivers and SF estuary.

Permit 14808-4M

Under permit 14808-4M, the California Department of Fish and Wildlife (CDFW) is seeking to modify a 5-year permit that currently allows them to take juvenile and adult SRWR and CVSR Chinook salmon, CCV steelhead and green sturgeon in the Central Valley of CA. The CDFW proposes to capture fish with rotary screw traps and to observe fish at weirs, fish ladders, dams and during snorkel surveys. Captured fish would be anesthetized, measured, weighed, tagged (acoustic, Floy, Elastomer, or PIT), have a tissue sample taken, allowed to recover, and released. The modification is requested because the original permit application included an indirect mortality rate of one percent for rotary screw trapping however the modification is requesting a three percent indirect mortality rate. The researchers do not intend to kill any listed fish as part of the requested modification, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 25, under the columns ‘Mod Total Take’ and ‘Mod Lethal Take.’ The columns ‘Prior Total Take’ and ‘Prior Lethal Take’ indicate the amounts of take previously authorized by this permit that will continue to be allowed under the modified permit. Only the additional take requested under this permit modification (i.e., take not previously authorized) is analyzed in this Opinion, as reflected in the ‘Percent of ESU/DPS’ columns.

Table 25. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 14808-4M.

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Mod Total Take	Mod Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central Valley spring-run Chinook salmon	Adult	Natural	C/M, T, ST/R	200	5	0	0	-	-
	Adult	Natural	O/H	1,550	0	0	0	-	-
	Adult	LHAC	C/M, T, ST/R	200	5	0	0	-	-
	Adult	LHAC	O/H	300	0	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	1,700	17	0	34	0.00	<0.01
	Juvenile	Natural	O/H	75,000	0	0	0	-	-
Sacramento River winter-run Chinook salmon	Adult	Natural	C/M, T, ST/R	100	2	0	0	-	-
	Adult	Natural	O/H	2,550	0	0	0	-	-
	Adult	LHAC	C/M, T, ST/R	100	2	0	0	-	-
	Adult	LHAC	O/H	525	0	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	2,050	21	0	40	0.00	0.02
	Juvenile	Natural	O/H	100,00 0	0	0	0	-	-
	Juvenile	LHAC	C/M, T, ST/R	1,000	10	0	20	0.00	0.01
	Juvenile	LHAC	IM	220	220	0	0	-	-

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Mod Total Take	Mod Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	LHAC	O/H	200,000	0	0	0	-	-
California Central Valley Steelhead	Adult	Natural	C/M, T, ST/R	305	10	0	0	-	-
	Adult	Natural	O/H	600	0	0	0	-	-
	Adult	LHAC	C/M, T, ST/R	1,505	30	0	0	-	-
	Adult	LHAC	O/H	50	0	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	100	1	0	2	0.00	<0.01
	Juvenile	Natural	O/H	150,000	0	0	0	-	-
	Juvenile	LHAC	C/M, T, ST/R	500	5	0	10	0.00	<0.01
Southern DPS green sturgeon	Adult	Natural	C/M, T, ST/R	20	1	0	0	-	-
	Subadult	Natural	C/M, T, ST/R	15	1	0	0	-	-
	Juvenile	Natural	C/H/R	5	1	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	10	1	0	0	-	-

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
O/H – Observe/Harass

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 25.

We expect at least 97 percent of fish captured for handling, sampling, and release to survive. We do not have reliable population-level abundance estimates for SRWR Chinook salmon. For CVSR Chinook salmon all take would occur at location in the Sacramento River below where individuals from individual populations would be mixed, and therefore the effects of sampling would be distributed across populations within this ESU. Therefore, we have analyzed the effects at the

ESU/DPS scale for these species. As the figures in Table 25, above, demonstrate the research under this modified permit would additionally kill at most 0.02% of the natural-origin juveniles of the SRWR Chinook salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at lower rates. For CCV steelhead, sampling would occur at a location where individuals from all populations for which we have estimates would be mixed except for juvenile outmigrants from the American and Mokelumne Rivers. In this case, the two natural-origin and 10 hatchery-origin juveniles potentially killed at this location would still result in a <0.01% impact to the estimated 457,617 natural-origin or 989,110 hatchery-origin outmigrating juveniles of the Sacramento River populations above the confluence with the American River.

Research associated with Permit modification 14808-4M would have only a very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program generating data regarding the outmigration of salmonids and timing, abundance, and size distribution of salmonids in the Sacramento River, and providing information about how environmental conditions (e.g., flow, temperature, and turbidity) affect downstream movement of juvenile salmonids.

Permit 15169-2R

Under permit 15169-2R, the National Park Service (NPS) Point Reyes Station is seeking to renew for five years a research permit that currently allows them to take juvenile and adult CC Chinook salmon, CCC coho, and CCC steelhead along the central coast of California. The NPS proposes to capture fish with nets (fyke, seine, beach), backpack electroshocking, weirs, and rotary screw traps and to observe fish during snorkel and spawning ground surveys. A subset of captured fish would be anesthetized, measured, weighed, tagged (acoustic, FLOY or PIT), dye injected (tattoo, photonic) have a tissue sample taken, have stomachs pumped for diet analysis, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.
The applicant is requesting the amounts of take shown in Table 26.

Table 26. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 15169-2R.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
California Coastal Chinook salmon	Adult	Natural	C/M, T, ST/R	120	2	1.71	0.03
	Adult	Natural	O/H	163	0	-	-
	Spawned Adult/ Carcass	Natural	O/ST D	63	0	-	-
	Juvenile	Natural	C/H/R	1,540	19	0.12	<0.01
	Juvenile	Natural	C/M, T, ST/R	545	8	0.04	<0.01

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	O/H	2,350	0	-	-
Central California Coast coho salmon	Adult	Natural	C/M, T, ST/R	1,420	19	73.50	0.98
	Adult	Natural	O/H	2,253	0	-	-
	Adult	Natural	O/ST D	4	0	- [a]	- [a]
	Adult	LHIA	C/M, T, ST/R	200	6	61.16	1.83
	Adult	LHIA	O/H	500	0	-	-
	Adult	LHIA	O/ST D	150	0	- [a]	- [a]
	Spawned Adult/ Carcass	Natural	O/ST D	456	0	-	-
	Spawned Adult/ Carcass	LHIA	O/ST D	150	0	-	-
	Juvenile	Natural	C/H/R	20,350	274	12.87	0.17
	Juvenile	Natural	C/M, T, ST/R	12,615	195	7.98	0.12
	Juvenile	Natural	O/H	33,400	0	-	-
	Juvenile	LHIA	C/H/R	3,000	30	1.81	0.02
	Juvenile	LHIA	C/M, T, ST/R	2,000	20	1.21	0.01
Central California Coast Steelhead	Adult	Natural	C/H/R	58	4	2.65	0.18
	Adult	Natural	C/M, T, ST/R	720	10	32.92	0.46
	Adult	Natural	O/H	530	0	-	-
	Adult	Natural	O/ST D	20	0	- [a]	- [a]
	Spawned Adult/ Carcass	Natural	O/ST D	190	0	-	-
	Juvenile	Natural	C/H/R	19,235	306	7.73	0.12
	Juvenile	Natural	C/M, T, ST/R	11,580	235	4.65	0.09
	Juvenile	Natural	O/H	46,700	0	-	-

[a] These are not included in calculations of effects on the ESU/DPS because samples are only collected from animals that have already perished.

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
O/H – Observe/Harass
O/ST D – Observe/Sample Tissue Dead Animal

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. While snorkel surveys and other observation methods that do not require capture would potentially impact large numbers of fish, the stress of such encounters is not expected to have measurable physiological, behavioral, or reproductive effects on fish. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 26.

We expect at least 97 percent of fish captured for handling, sampling, and release to survive. As the figures in Table 24, above, demonstrate the research under this permit would kill at most 1.83% of the hatchery-origin adults of the CCC coho salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at lower rates (i.e., less than one percent). The effects of this sampling will be spread out over many tributaries and multiple basins over a broad area, and spread out in such a way that it is difficult to examine the impacts at a population level. We also do not have reliable population-level abundance estimates for listed species in all of the watersheds proposed to be sampled by this permit. For CC Chinook salmon, sampling is occurring just outside of the watersheds included in the ESU, and therefore effects of capturing individuals in this area (outside of individual population watersheds) is assumed to be spread across the ESU. Therefore, we have only analyzed the effects at the ESU/DPS scale for CC Chinook salmon. For CCC coho, abundance data only exist for a subset of the populations in which take will occur, and these estimates are believed to be underestimates of the true population abundance for reasons discussed in more detail below. Still, considering the abundance data that are available the potential population-level effects for CCC coho would be, at most, as follows:

Population	Life Stage	Origin	Total Take	Lethal Take	Population Abundance	Percent Killed
Lagunitas Creek	Adult	Natural	1,000	10	408	2.45
	Juvenile	Natural	13,505	166	28,560	0.58
Pine Gulch Creek	Adult	Natural	150	2	2	100
	Juvenile	Natural	1,250	15	140	10.71
Redwood Creek	Adult	Natural	150	2	23	8.70
	Juvenile	Natural	7,340	114	1,610	7.08
San Vicente Creek	Juvenile	Natural	130	2	140	1.43

[a]Expected abundance from nearby Russian River hatchery releases

Similarly for CCC steelhead, considering the abundance data that are available the potential population-level effects would be, at most, as follows:

Population	Life Stage	Origin	Total Take	Lethal Take	Population Abundance	Percent Killed
Lagunitas Creek	Adult	Natural	525	6	70	8.57
	Juvenile	Natural	11,505	196	8,076	2.43
Pine Gulch Creek	Adult	Natural	80	2	37	5.41
	Juvenile	Natural	3,750	59	4,209	1.40
Redwood Creek	Adult	Natural	58	2	18	11.11
	Juvenile	Natural	5,705	115	2,048	5.62
San Vicente Creek	Juvenile	Natural	250	6	3,981	0.15

In addition to the low absolute numbers of fish expected to be handled or killed as a result of this research, it is important to note that the percent of ESU taken or killed calculated above is almost certainly an overestimate. The abundance data to which take levels are compared are limited, and only capture a portion of the ESU or DPS unit represented, both because complete data are not collected for all populations in these units and sampling often does not capture the entirety of a run or spawning season. Therefore, the actual abundance values for these species are larger than those displayed in Table 23 and Section 2.2.1, and the requested take would impact a smaller proportion of the entire ESU, DPS, or component population than what is estimated in Table 26 using available data.

We also anticipate that the actual take and mortality associated with this work will be lower than the levels authorized here based on previous years of sampling. Our take tracking system indicates that for prior years of this study, since 2013 only 4.6% of the requested handling (i.e., non-observation) take (23,044 of 500,358 individuals) and 1.2% of the requested mortalities (110 of 9,015) have occurred. This indicates that impacts of this research on the ESU/DPS level as well as at the population level will be only a similarly small fraction of the maximum take being authorized.

Lastly, the component of any population expected to be most impacted by this research is the hatchery component of adult CCC coho. While hatchery-origin fish are listed as part of this ESU, they are not considered as valuable to the survival and recovery of this ESU as the naturally reproducing adults, assumed to be better adapted to the local habitat conditions and carry higher genetic diversity to contribute to the population than hatchery origin-fish. Impacts to the abundance of this component of the ESU therefore likely have less of an impact on the productivity and diversity than impacts to natural-origin adults.

Research associated with Permit 15196-2R would therefore have a minor impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program generating data regarding juvenile salmonid outmigration, distribution, abundance and diet composition, and adult salmonid spawning and escapement in Tomales Bay, as well as winter habitat use and fish movements within the bay.

Permit 16344-3R

Under permit 16344-3R, Oregon State University is seeking to renew for five years a research permit that currently allows them to take juvenile listed hatchery SONCC coho in the Upper Klamath River. Juvenile coho salmon from Iron Gate and/or Trinity River hatcheries would be transported to selected locations on the Klamath River and monitored for disease after the exposure to *C. shasta.* Following exposure, all fish would be transported to the Oregon State University J. L. Fryer Aquatic Animal Health Laboratory where time to morbidity, overall morbidity and infection prevalence would be ascertained through microscopic and molecular analysis of intestinal tissues.

The applicant is requesting the amounts of take shown in Table 27.

Table 27. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under Permit 16344-3R.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Southern Oregon/Northern California Coast coho salmon	Juvenile	LHIA	C,S,T	540	0	0.09	0.00
	Juvenile	LHIA	IM	300	300	0.05	0.05

C,S,T – Capture, Sample, Transport Live Animal
IM – Intentional (Directed) Mortality

It should be noted that the values in Table 27, above, are redundant because the same juveniles collected and transported are those that will be later euthanized for analysis. Because all of the treatment fish will be exposed to the parasite *C. shasta*, they can not be released after the experiments. In addition, infection prevalence data are needed which requires euthanizing all fish surviving the exposures, since surviving fish may still be infected with the parasite. Control fish will also be euthanized at the termination of the study. However, all of these fish will be obtained directly from hatcheries and are not expected to decrease the hatchery releases for this ESU, so these mortalities are not expected to impact the ESU.

To determine the effects of potential research losses, we compare the numbers of fish that will be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 27. As discussed above, the juveniles taken for this study will be collected directly from hatchery brood and not yet released into a particular population area. Therefore, we have analyzed the effects at the ESU/DPS scale. As the figures in Table 27, above, demonstrate the research under this permit would kill at most 0.05% of the hatchery-origin juvenile component of the SONCC coho salmon ESU. However, as these fish are expected to be in excess of what hatcheries will produce to meet their juvenile release objectives, we do not expect juvenile releases to be decreased or the abundance of the ESU to be affected by this research.

Research associated with Permit 16344-3R would have only very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing research to determine the effects of infection by the myxozoan parasite *Ceratonova shasta* on coho salmon, and estimate disease effects for each study year on the wild coho population for this ESU.

Permit 16491-3R

Under permit 16491-3R, Fawcett Ecological Consulting is seeking to renew for five years a research permit that currently allows them to take juvenile CC Chinook salmon, CCC coho and CCC steelhead in coastal Northern California streams. The applicant proposes to capture fish using beach seines and to observe fish during snorkel and spawning ground surveys. A subset of captured fish would be anesthetized, measured, weighed, tagged (FLOY), have a tissue sample taken, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 28.

Table 28. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 16491-3R.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
California Coastal Chinook salmon	Spawned Adult/ Carcass	Natural	O/ST D	20	0	-	-
	Juvenile	Natural	C/M, T, ST/R	50	1	<0.01	<0.01
	Juvenile	Natural	O/H	150	0	-	-
Central California Coast coho salmon	Adult	Natural	O/H	40	0	-	-
	Adult	LHIA	O/H	40	0	-	-
	Spawned Adult/ Carcass	Natural	O/ST D	50	0	-	-
	Spawned Adult/ Carcass	LHIA	O/ST D	50	0	-	-
	Juvenile	Natural	C/H/R	150	3	0.09	0.00
	Juvenile	Natural	C/M, T, ST/R	400	8	0.25	0.01
	Juvenile	Natural	O/H	1,000	0	-	-
Central California Coast Steelhead	Spawned Adult/ Carcass	Natural	O/ST D	25	0	-	-
	Juvenile	Natural	C/H/R	200	4	0.08	<0.01

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	C/M, T, ST/R	550	11	0.22	<0.01
	Juvenile	Natural	O/H	1,300	0	-	-

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
O/H – Observe/Harass
O/ST D – Observe/Sample Tissue Dead Animal

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. While snorkel surveys and other observation methods that do not require capture would potentially impact large numbers of fish, the stress of such encounters is not expected to have measurable physiological, behavioral, or reproductive effects on fish. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 28.

We expect at least 97 percent of fish captured for handling, sampling, and release to survive. We do not have reliable population-level abundance estimates for listed species in the watersheds proposed to be sampled by this permit. Therefore, the effects of sampling are assumed to be distributed across the populations and we have analyzed the effects at the ESU/DPS scale. As the figures in Table 28, above, demonstrate the research under this permit would kill at most 0.01% of the natural-origin juveniles in the CCC coho salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at even lower rates.

Research associated with Permit 16491-3R would have only a very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program generating data regarding salmonid populations in Salmon Creek, Sonoma County in relation to habitat restoration and coho restocking efforts, and the genetics, variability in abundance, and life histories of steelhead in small coastal streams.

Permit 16506-3R

Under permit 16506-3R Mike Podlech, an independent researcher, is seeking to renew for five years a research permit that currently allows him to take juvenile and adult CCC coho and steelhead in Squaw and Pescadero creeks in Sonoma and San Mateo counties. The applicant proposes to capture fish with a fyke net and backpack electrofishing. A subset of the captured fish would be anesthetized, measured, weighed, have a tissue sample taken, allowed to recover, and released. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 29.

Table 29. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 16506-3R.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central California Coast coho salmon	Adult	Natural	C/H/R	3	0	0.16	0.00
	Juvenile	Natural	C/H/R	700	7	0.44	<0.01
	Juvenile	Natural	C/M, T, ST/R	100	0	0.06	0.00
Central California Coast Steelhead	Adult	Natural	C/H/R	5	0	0.23	0.00
	Juvenile	Natural	C/H/R	4,350	43	1.75	0.02
	Juvenile	Natural	C/M, T, ST/R	450	5	0.18	<0.01

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 29.

We expect at least 97 percent of fish captured for handling, sampling, and release to survive. We do not have reliable population-level abundance estimates for listed species in all of the watersheds proposed to be sampled by this permit. For CCC coho salmon, limited population information in Pescadero Creek suggests an estimated minimum of 70 juvenile outmigrants, and therefore the maximum authorized take (seven juveniles) would comprise 10% of the naturally-produced juveniles in this population. For CCC steelhead, the maximum authorized lethal take in Pescadero Creek (40 juveniles) would comprise 0.1% of the naturally-produced juveniles in this population (41,064). , However, it is important to note that the percent of the population (and ESU) taken or killed is almost certainly an overestimate. The abundance data to which take levels are compared are limited, and only capture a portion of the ESU or DPS unit represented, both because complete data are not collected for all populations in these units and sampling often does not capture the entirety of a run or spawning season. Therefore, the actual abundance values for these species are larger than those displayed in Table 23 and Section 2.2.1, and the requested take would impact a smaller proportion of the entire ESU, DPS, or component population than what is estimated in Table 29 using available data.

Analysis of effects at the ESU/DPS scale (in Table 29, above) demonstrates the research under this permit would kill at most 0.02% of the natural-origin juveniles in the CCC steelhead DPS. All other age/origin components of listed ESUs/DPSs would be impacted at lower rates.

We also anticipate that the actual take and mortality associated with this work will be lower than the levels authorized here based on previous years of sampling. Our take tracking system indicates that for prior years of this study, since 2013 only 5.3% of the requested take (1,792 of 33,648 individuals) and 12.4% of the requested mortalities (41 of 330) have occurred. This indicates that impacts of this research on the ESU/DPS level as well as at the population level will be only a fraction of the maximum take being authorized.

Research associated with Permit 16506-3R would have only a very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program generating data regarding CCC steelhead population trends in Squaw and Pescadero creeks, potential presence of wild progeny from coho salmon hatchery releases in Pescadero Creek, and population data used to inform ongoing watershed restoration and salmonid recovery efforts.

Permit 17551-3R

Under this permit, the CDFW is seeking to renew for five years a research permit that currently allows them to take juvenile green sturgeon, adult CCV steelhead, and adult SRWR and CVSR Chinook salmon in the Sacramento-San Joaquin Delta in San Francisco Bay, CA. The applicant proposes to capture fish with a gill net. Captured green sturgeon would be anesthetized, measured, weighed, tagged (acoustic or sonic), have a tissue sample taken, allowed to recover, and released. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 30.

Table 30. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 17551-3R.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central Valley spring-run Chinook salmon	Adult	Natural	C/H/R	2	1	0.05	0.03
	Adult	LHAC	C/H/R	2	1	0.09	0.04
Sacramento River winter-run Chinook salmon	Adult	Natural	C/H/R	2	1	0.95	0.48
	Adult	LHAC	C/H/R	2	1	0.09	0.04
California Central Valley Steelhead	Adult	Natural	C/H/R	2	2	0.12	0.12

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Southern DPS green sturgeon	Juvenile	Natural	C/M, T, ST/R	100	2	4.75	0.09

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal

High percentages of salmonids unintentionally captured with gill nets are expected to die as a result of capture, however very few adult salmonids are anticipated to be encountered. The majority of the green sturgeon that would be captured with gill nets are expected to recover with no adverse physiological, behavioral, nor reproductive effects. Therefore, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 30.

We expect at least 97 percent of sDPS green sturgeon captured for handling, sampling, tagging and release to survive. We expect up to half of the adult salmonids captured may be killed with this sampling method. Sampling under this permit will occur in the lower Sacramento River and Montezuma Slough where individuals from multiple populations within an ESU or DPS are mixed. Therefore, we have analyzed the effects at the ESU/DPS scale. As the figures in Table 30, above, demonstrate the research under this permit would kill at most 0.48% of the natural-origin adults in the SRWR Chinook salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at lower rates. Additionally, we do not expect the authorized rates of mortality for salmonids to occur on an annual basis based on previous years of sampling. Our take tracking system indicates that during prior years of this study, since 2013 there have been no mortalities of salmonids and only two mortalities of sDPS green sturgeon. Therefore, it is likely less than one adult of any salmonid ESU or DPS will be killed per year for the duration of this permit.

Research associated with Permit 17551-3R would have a very minor impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program generating data regarding juvenile green sturgeon movement, emigration patterns, survival, timing of Pacific Ocean entry, and subsequent ocean migration patterns.

Permit 19400-3R

Under permit 19400-3R, ICF Consulting is seeking to renew for five years a research permit that currently allows them to take juvenile natural and listed hatchery SRWR and CVSR Chinook salmon, CCV steelhead and juvenile green sturgeon in Suisan Bay, CA. The applicant proposes to capture fish with seines (beach, Lampara), nets (fyke), and trawls (midwater, otter). This study would result in the capture, handle, and release of juvenile green sturgeon and intentional directed mortality of juvenile salmon for isotopic and otolith analysis.

The applicant is requesting the amounts of take shown in Table 31.

Table 31. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 19400-3R.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central Valley spring-run Chinook salmon	Juvenile	Natural	IM	50	50	0.01	0.01
	Juvenile	LHAC	IM	50	50	0.00	<0.01
Sacramento River winter-run Chinook salmon	Juvenile	Natural	IM	25	25	0.01	0.01
	Juvenile	LHAC	IM	25	25	0.01	0.01
California Central Valley Steelhead	Juvenile	Natural	IM	25	25	0.00	<0.01
	Juvenile	LHAC	IM	25	25	0.00	<0.01
Southern DPS green sturgeon	Juvenile	Natural	C/H/R	5	0	0.24	<0.01

C/H/R – Capture/Handle/Release
IM – Intentional (Directed) Mortality

Juvenile salmonids captured in this study are intended to be euthanized for analysis, although relatively small numbers of fish would be used for this purpose. The effects of the proposed action considered herein are therefore best seen in the context of the fish that are likely to be killed. 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 population and species. These figures are presented in the far-right column of Table 31. All sDPS green sturgeon that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects.

This sampling is to be conducted only in areas that are not specific to particular watersheds or populations, where the effects are evenly distributed across the ESUs or DPS. Therefore, we have analyzed the effects at the ESU/DPS scale. As the figures in Table 31, above, demonstrate the research under this permit would kill at most 0.01% of the natural-origin juveniles of the CVSR Chinook salmon ESU and the hatchery-origin and natural-origin juveniles of the SRWR Chinook salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at even lower rates.

Research associated with Permit 19400-3R would have only a very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by supporting an ongoing monitoring program generating data regarding the spatial and temporal distribution and abundance of juvenile Chinook salmon in shallow water habitats used to validate to predictions from habitat suitability models. This work would also provide baseline fish and invertebrate samples for a Before-After Control-Impact (BACI) study design to assess the impact of a planned breach at the Tule Red restoration site.

Permit 22270

Under permit 22270, the Wiyot tribe is seeking a five-year research permit that would allow them to annually take juvenile NC steelhead in the South Fork of the Eel River, CA. The applicant proposes to target pikeminnow capture with backpack and boat electrofishing, fyke net, seine, baited frame traps, dip netting, hook-and line, spearfishing, angling and to observe fish during snorkel surveys. A subset of listed salmonids captured in conjunction with this work would be anesthetized, measured, weighed, have a tissue sample taken, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research

The applicant is requesting the amounts of take shown in Table 32.

Table 32. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 22270.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Northern California Steelhead	Juvenile	Natural	C/H/R	21	5	<0.01	<0.01
	Juvenile	Natural	C/M, T, ST/R	10	1	<0.01	<0.01
	Juvenile	Natural	O/H	30	0	-	-

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
O/H – Observe/Harass

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. While snorkel surveys and other observation methods that do not require capture would potentially impact larger numbers of fish, the stress of such encounters is not expected to have measurable physiological, behavioral, or reproductive effects on fish. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 32.

We expect at least 97 percent of fish captured for handling, sampling, and release to survive, although this study considers such small numbers of fish that a single mortality event could exceed a 3% rate for either capture take action. At the population level, the six authorized mortalities still represent less than 0.01% of the abundance of naturally produced juveniles in the South Fork Eel

River. At the ESU/DPS scale the figures in Table 30, above, demonstrate the research under this permit would kill less than 0.01% of any age/origin components of listed ESUs/DPSs that could be impacted by this work.

Research associated with Permit 22270 would have only a very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by evaluating the impacts of Sacramento pikeminnow, a non-native predator, on Pacific lamprey, steelhead, and other native species, and developing and testing methods for pikeminnow population suppression in terms of catch-per-unit-effort and cost-per-fish captured.

Permit 22303

Under permit 22303, the NOAA Fisheries California Central Valley office is seeking a five year research permit that would allow them to annually take adult LCR, SRWR, CVSR, and CC Chinook salmon, as well as subadult and adult green sturgeon. In this study, researchers would test the use of DIDSON cameras in the CHBT nets to characterize the physical interaction between green sturgeon and CHBT nets. Study results would be used to evaluate methods to minimize gear interactions and bycatch of green sturgeon. The applicant proposes to capture fish with a bottom trawl. Captured green sturgeon would be captured, handled and released. The researchers would avoid adult salmonids, but some may be encountered as an unintentional result of sampling. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 33.

Table 33. Proposed take and comparison of possible lethal take to annual abundance at the ESU scale under permit 22303.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Lower Columbia River Chinook salmon	Adult	Natural	IM	1	1	<0.01	<0.01
California Coastal Chinook salmon	Adult	Natural	IM	1	1	0.01	0.01
Central Valley spring-run Chinook salmon	Adult	Natural	IM	1	1	0.03	0.03
Sacramento River winter-run Chinook salmon	Adult	Natural	IM	3	3	1.43	1.43
Southern DPS green sturgeon	Adult	Natural	C/H/R	1	0	0.02	0.00
	Subadult	Natural	C/H/R	42	4	0.38	0.04

C/H/R – Capture/Handle/Release

IM – Intentional (Directed) Mortality; while these are noted as 'intentional' mortalities because all adult salmonids encountered by the trawl gear are expected to be killed, it is not the objective of this study to kill listed salmonids so they are not truly 'intentional.'

High percentages of salmonids unintentionally captured with bottom trawls are expected to die as a result of capture, however very few adult salmonids are anticipated to be encountered. The majority of the green sturgeon that would be captured with bottom trawl gear are expected to recover with no adverse physiological, behavioral, nor reproductive effects. Therefore, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 33.

We expect at least 90 percent of sDPS green sturgeon captured to survive. We expect all adult salmonids captured may be killed. This sampling is to be conducted in an area that is not specific to particular watersheds or populations, where the effects are evenly distributed across the ESUs or DPS. Therefore, we have analyzed the effects at the ESU/DPS scale. As the figures in Table 31, above, demonstrate the research under this permit would kill at most 1.43% of the natural-origin adults in the SRWR Chinook salmon ESU. All other age/origin components of listed ESUs/DPSs would be impacted at lower rates (i.e., 0.04 percent or less).

In addition to the low absolute numbers of fish expected to be handled or killed as a result of this research, it is important to note that the percent of ESU taken or killed calculated above is almost certainly an overestimate. The abundance data to which take levels are compared are limited, and only capture a portion of the ESU or DPS unit represented, both because complete data are not collected for all populations in these units and sampling often does not capture the entirety of a run or spawning season. Therefore, the actual abundance values for these species are larger than those displayed in Table 23 and Section 2.2.1, and the requested take would impact a smaller proportion of the entire ESU, DPS, or component population than what is estimated in Table 33 using available data.

In addition, the NOAA Fisheries CCV office reviewed the West Coast Groundfish Observer Program Data to predict the maximum number of adult salmonids that may reasonably be encountered during this work. These data also suggest researchers are likely to encounter fewer than three individual adult SRWR Chinook salmon, particularly on an annual basis when averaged over the five year permit.

Research associated with Permit 22303 would have a very minor impact on abundance, productivity, spatial structure or diversity for these listed species with the exception of SRWR Chinook salmon, for which it would have a small impact. Results from this study would benefit listed species characterizing the physical interaction between green sturgeon and the halibut bottom trawl fishery operating out of Half Moon and San Francisco bays.

Permit 22700

Under permit 22700, the Monterey Bay Salmon and Trout Project (MBSTP) is seeking a five-year research permit that would allow them to annually take adult CC coho and CCC steelhead in the San Lorenzo River, CA. The applicant proposes to capture fish at the Felton Diversion Facility weir.

Captured adult steelhead would be measured, weighed, PIT tagged, have a tissue sample taken, allowed to recover, and released. Adult coho would be captured, handled and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 34.

Table 34. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 22700.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central California Coast coho salmon	Adult	Natural	C/H/R	3	0	0.16	0.00
Central California Coast Steelhead	Adult	Natural	C/H/R	50	1	2.29	0.05
	Adult	Natural	C/M, T, ST/R	350	3	16.00	0.14

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 34.

We expect at least 97 percent of fish captured for handling, sampling, tagging and release to survive.. No CCC coho are expected to be killed as a result of this sampling. At the population level, lethal take of 4 adult CCC steelhead only represents 0.95% of the minimum of 423 natural-origin adult abundance estimated for the San Lorenzo River population. At the ESU/DPS scale, the figures in Table 32, above, demonstrate the research under this permit would kill at most 0.19% of the natural-origin adults in the CCC steelhead DPS overall.

Research associated with Permit 22700 would have a minor impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by gathering genetic and life history data on CCC steelhead that will contribute to large-scale salmonid monitoring programs on the San Lorenzo River currently being implemented by the City and County of Santa Cruz.

Permit 22939

Under permit 22939, Tim Salamunovich of TRPA Fish Biologist is seeking a 5-year research permit that would allow him to annually take juvenile SRWR and CVSR Chinook salmon, CCV steelhead and green sturgeon in a central valley delta wetland area known as The Big Ditch on the Peterson Ranch in eastern Solano County, California. The applicant proposes to capture fish with beach seines and minnow traps. Captured fish would be anesthetized, measured, weighed, allowed to recover, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The applicant is requesting the amounts of take shown in Table 35.

Table 35. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 22939.

Species	Life Stage	Origin	Take Action	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central Valley spring-run Chinook salmon	Juvenile	Natural	C/H/R	170	5	0.02	<0.01
Sacramento River winter-run Chinook salmon	Juvenile	Natural	C/H/R	170	5	0.09	<0.01
California Central Valley Steelhead	Juvenile	Natural	C/H/R	170	5	0.03	<0.01
Southern DPS green sturgeon	Juvenile	Natural	C/H/R	10	0	0.47	0.00

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 35.

We expect at least 97 percent of fish captured for handling, sampling, tagging and release to survive. This sampling is to be conducted in an estuarine area that is not specific to particular watersheds or populations, where the effects are evenly distributed across the ESUs or DPS. Therefore, we have analyzed the effects at the ESU/DPS scale.. Therefore, we have analyzed the effects at the ESU/DPS scale. As the figures in Table 35, above, demonstrate the research under this permit would kill <0.01% of any age/origin components of listed ESUs/DPSs that would be impacted by this work.

Research associated with Permit 22939 would have only very minor to no impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by collecting seasonal presence/absence and relative abundance data to document seasonal fish use throughout the Big Ditch project area in order to document the baseline conditions prior to restoration efforts.

Permit 16318-3M

Under permit 16318-3M Hagar Environmental Science (HES) is seeking to modify a 5-year permit that currently allows them to take juvenile and smolt CCC coho salmon, CCC steelhead, and SCCC steelhead in the San Lorenzo River (including Newell Creek, Zayante Creek, and Mountain Charlie Creek), Liddell Creek, Laguna Creek, and Majors Creek in Santa Cruz County, and in the Salinas River (including Arroyo Seco River, Nacimiento River, San Antonio River, and upper tributaries) in Monterey and San Luis Obispo Counties, CA. HES proposes to capture fish with beach seines and backpack electrofishing. Fish would be enumerated, measured, and observed for external condition. A subset of the captured fish would be anesthetized, measured, weighed, PIT tagged, have a tissue sample taken, allowed to recover, and released. HES would also observe fish during snorkel/dive surveys. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research. This modification is requested to increase the number of juvenile CCC steelhead because the researchers encountered greater numbers of CCC steelhead than were authorized in the existing permit.

The applicant is requesting the amounts of take shown in Table 36, under the columns ‘Mod Total Take’ and ‘Mod Lethal Take.’ The columns ‘Prior Total Take’ and ‘Prior Lethal Take’ indicate the amounts of take previously authorized by this permit that will continue to be allowed under the modified permit. Only the additional take requested under this permit modification (i.e., take not previously authorized) is analyzed in this Opinion, as reflected in the ‘Percent of ESU/DPS’ columns.

Table 36. Proposed take and comparison of possible lethal take to annual abundance at the ESU scale under permit 16318-3M.

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Mod Total Take	Mod Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central California Coast coho salmon	Juvenile	Natural	C/H/R	600	6	0	6	0.00	<0.01
	Juvenile	Natural	O/H	400	0	0	0	-	-
	Juvenile	LHIA	C/H/R	20	1	0	0	-	-
Central California Coast Steelhead	Juvenile	Natural	C/H/R	2,600	39	10,200	89	4.10	0.04
	Juvenile	Natural	C/M, T, ST/R	2,740	50	3,840	82	1.54	0.03
	Juvenile	Natural	O/H	2,400	0	0	0	-	-
South-Central California	Juvenile	Natural	C/H/R	1,760	22	0	0	-	-
	Juvenile	Natural	C/M, T, ST/R	80	0	0	3	0.00	<0.01

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Mod Total Take	Mod Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Coast Steelhead	Juvenile	Natural	O/H	1,440	0	0	0	-	-

C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
O/H – Observe/Harass

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. While snorkel surveys and other observation methods that do not require capture would potentially impact large numbers of fish, the stress of such encounters is not expected to have measurable physiological, behavioral, or reproductive effects on fish. To determine the effects of these research losses, it is therefore necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. These figures are presented in the far-right column of Table 36.

We expect at least 97 percent of fish captured for handling, sampling, and release to survive. For CCC coho, lethal take of up to six natural-origin juveniles represents 8.57% of the abundance of the San Lorenzo River population. For CCC steelhead, the potential lethal take of 171 natural-origin juveniles represents 0.36% of the San Lorenzo River population abundance (estimated as 48,116 natural origin juveniles). For SCCC steelhead, lethal take of up to three natural-origin juveniles represents 0.13% of the natural-origin juveniles in the Salinas River population.. At the ESU/DPS scale the figures in Table 34, above, demonstrate the research under this permit would kill at most 0.07% of the natural-origin juveniles in the CCC steelhead DPS. All other age/origin components of listed ESUs/DPSs would be impacted at even lower rates.

In addition to the low absolute numbers of fish expected to be handled or killed as a result of this research, it is important to note that the percent of population or ESU/DPS taken or killed calculated above is almost certainly an overestimate. The abundance data to which take levels are compared are limited, and only capture a portion of the ESU or DPS unit represented, both because complete data are not collected for all populations in these units and sampling often does not capture the entirety of a run or spawning season. Therefore, the actual abundance values for these species are larger than those displayed in Table 23 and Section 2.2.1, and the requested take would impact a smaller proportion of the entire ESU, DPS, or component population than what is estimated in Table 36 using available data.

Research associated with Permit 16318-3M would have a minor impact on abundance, productivity, spatial structure or diversity for these listed species. Results from this study would benefit listed species by providing ESA-listed salmonid population, distribution, and habitat assessment data to inform watershed management, as well as establish baseline population abundances preceding the implementation of habitat conservation measures.

2.6 Cumulative Effects

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

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

In developing this biological opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed salmonids—primarily the final recovery plans and efforts laid out in the 2011 and 2016 status review updates (see Section 2.2.2). The result of those reviews was that salmon take—particularly associated with research, monitoring, and habitat restoration—is likely to continue to increase in the region for the foreseeable future. However, as noted above, most actions falling in those categories would also have to undergo consultation (like that documented in this opinion) before they are allowed to proceed.

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

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

Because the action area falls entirely within designated critical habitat and navigable marine 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, habitat management, 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, sturgeon, rockfish, eulachon, or their habitat, and therefore the effects such a project may have on listed species will be analyzed when the need arises.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.3).

In developing this biological opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed species—primarily final recovery plans and efforts laid out in the Status review updates for Pacific salmon and steelhead listed under the Endangered Species Act.[3] The recovery plans, status summaries, and limiting factors that are part of the analysis of this Opinion are referenced in Table 2 (Section 2.2.1).

The result of that review 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 in this opinion) before they are allowed to proceed.

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities, make any analysis of cumulative effects difficult and speculative. For more information on the various efforts being made at the local, tribal, state, and national levels to conserve PS Chinook salmon and other listed salmonids, see any of the recent status reviews, listing Federal Register notices, and recovery planning documents, as well as recent consultations on issuance of section 10(a)(1)(A) research permits.

Thus, non-Federal activities are likely to continue affecting listed species and habitat within the action area. These 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 economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, it seems likely that they will continue to increase as a general pattern over time. 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 the Pacific Northwest and elsewhere that will not undergo ESA consultation. Although many state, tribal, and local governments have developed plans and

[3] NOAA Fisheries – West Coast Region - 2016 Status Reviews of Listed Salmon & Steelhead

initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them “reasonably foreseeable” in its analysis of cumulative effects.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat that would result from implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency’s biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

Aside from the considerations listed above, these assessments 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 37), (b) add the take proposed by the researchers in this opinion to the take that has already been authorized in the region (Table 38), and then (c) compare those totals to the estimated annual abundance of each species under consideration.

Table 37. Total requested take and percentages of the ESU/DPS affected for each ESA listed species taken under permits covered in this Biological Opinion.

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Lower Columbia River Chinook salmon	Adult	Natural	1	1	<0.01	<0.01
California Coastal Chinook salmon	Adult	Natural	121	3	1.72	0.04
	Juvenile	Natural	2,135	28	0.17	<0.01
Central Valley spring-run Chinook salmon	Adult	Natural	40	5	1.07	0.13
		LHAC	29	4	1.28	0.18
	Juvenile	Natural	220	89	0.03	0.01
		LHAC	50	50	<0.01	<0.01
Sacramento River winter-run Chinook salmon	Adult	Natural	32	6	15.24	2.86
		LHAC	23	3	1.03	0.13
	Juvenile	Natural	195	70	0.10	0.04
		LHAC	25	45	0.01	0.02

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	-	-	-	-
	Juvenile	Natural	-	-		
		LHIA	840	300	0.15	0.05
Central California Coast coho salmon	Adult	Natural	1,426	19	73.81	0.98
		LHIA	200	6	61.16	1.83
	Juvenile	Natural	34,315	493	21.70	0.31
		LHIA	5,000	50	3.01	0.03
Northern California Steelhead	Adult	Natural	-	-	-	-
	Juvenile	Natural	31	6	0.00	0.00
California Central Valley Steelhead	Adult	Natural	83	10	4.92	0.59
		LHAC	81	8	2.10	0.21
	Juvenile	Natural	195	32	0.03	0.01
		LHAC	25	35	<0.01	<0.01
Central California Coast Steelhead	Adult	Natural	1,183	18	54.09	0.82
	Juvenile	Natural	50,405	775	20.26	0.31
South-Central California Coast Steelhead	Adult	Natural	-	-	-	-
	Juvenile	Natural	0	3	0.00	<0.01
Southern DPS green sturgeon	Adult	Natural	17	0	0.39	
	Subadult	Natural	42	4	0.38	0.04
	Juvenile	Natural	115	2	5.46	0.09
	Larvae	Natural	0	0	-	-

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.

Thus the activities contemplated in this opinion may kill—in combination and at most—as much as 2.86% of the fish from any component of any listed species; that component is adult natural-origin SRWR Chinook salmon. Because of the low estimates available for the current population abundance of SRWR Chinook salmon this figure represents the possible death of only six adult natural-origin SRWR Chinook salmon. In all other instances the effect is a fraction of that amount and, in many cases, orders of magnitude smaller. As noted previously, for SRWR Chinook salmon and many species analyzed in this opinion that the percent of ESU/DPS taken or killed calculated above is almost certainly an overestimate. The abundance data to which take levels are compared are often highly uncertain and only capture a portion of the ESU or DPS unit represented. Therefore, the actual abundance values for these species are larger than those displayed in Table 23, and the requested take would actually impact a smaller proportion of the entire ESU or DPS than what is estimated above. Before engaging further in the discussion of why take is expected to be much lower than these estimates in actuality, it is first 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 38). Because the majority of the fish that researchers capture and release are expected to recover shortly after handling with no long-term ill effects, the most meaningful effect of the action we consider here is the potential number of dead fish from each species. This signifies that all the research authorized for the species considered here—in combination with the proposed activities in this opinion—would have the following impacts in terms of the fish that may be killed.

Table 38. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2019 plus the permits covered in this Biological Opinion.

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Lower Columbia River Chinook salmon	Adult	Natural	372	7	1.26	0.02
		LHIA	12	0	0.36[b]	0.01[b]
		LHAC	128	2		
	Juvenile	Natural	819,725	11,369	6.91	0.10
		LHIA	444	53	0.04	<0.01
		LHAC	62,575	1,466	0.19	<0.01
California Coastal Chinook salmon	Adult	Natural	1,146	35	16.29	0.50
	Juvenile	Natural	309,222	3,962	24.19	0.31
Central Valley spring-run Chinook salmon	Adult	Natural	737	27	19.77	0.72
		LHAC	565	56	24.86	2.46
	Juvenile	Natural	873,766	16,921	112.68	2.18
		LHAC	19,080	3,093	0.88	0.14
Sacramento River winter-run Chinook salmon	Adult	Natural	305	17	145.24	8.10
		LHAC	220	56	9.86	2.51
	Juvenile	Natural	175,720	5,147	89.95	2.63
		LHAC	12,571	1,536	6.29	0.77
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	1,575	25	17.37	0.28
		LHIA	1,577	17	19.84[b]	0.25[b]
		LHAC	592	10		
	Juvenile	Natural	190,139	2,699	9.44	0.13

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		LHIA	11,991	681	2.09	0.12
		LHAC	1,456	42	0.73	0.02
Central California Coast coho salmon	Adult	Natural	3,664	53	189.65	2.74
		LHIA	1,697	37	518.96	11.31
	Juvenile	Natural	202,683	3,728	128.17	2.36
		LHIA	72,166	1,467	43.50	0.88
		LHAC	25,390	762	-[c]	-[c]
Northern California Steelhead	Adult	Natural	2,757	18	38.18	0.25
	Juvenile	Natural	254,447	4,108	30.98	0.50
California Central Valley Steelhead	Adult	Natural	3,386	94	200.83	5.58
		LHAC	2,090	104	54.20	2.70
	Juvenile	Natural	62,847	2,035	9.97	0.32
		LHAC	24,706	1,448	1.54	0.09
Central California Coast Steelhead	Adult	Natural	2,736	50	125.10	2.29
		LHAC	482	17	12.47	0.44
	Spawned Adult/ Carcass	Natural	265	4	-	-
		LHAC	100	2	-	-
	Juvenile	Natural	240,250	5,397	96.57	2.17
		LHIA	6,200	124	-	-
		LHAC	11,681	319	1.80	0.05
South-Central California Coast Steelhead	Adult	Natural	547	6	78.71	0.86
	Spawned Adult/ Carcass	Natural	20	1	-	-
	Juvenile	Natural	49,124	1,245	62.14	1.57
Southern DPS green sturgeon	Adult	Natural	193	5	4.40	0.11
	Subadult	Natural	82	6	0.74	0.05
	Juvenile	Natural	1,726	113	81.96	5.37
	Larvae	Natural	11,015	1,015	-	-
	Egg	Natural	1,350	1,350		

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.

[c] These rows represent previously authorized take, however there are no current abundance data for LHAC juveniles because starting with the 2012/2013 year class only intact adipose juveniles have been released from this hatchery program.

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 fourteen cases involving 7 species the potential mortality included in this opinion and all previously authorized research could amount to a more substantial percentage of an ESU component (i.e., life stage and origin) (Table 38). Therefore, we will review the potential mortality for each species by origin and life stage.

Salmonid Species

Lower Columbia River Chinook salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for LCR Chinook salmon would range from 0 to 0.1 percent of estimated species abundance—depending on the origin and life stage (Table 38). The potential mortality for natural origin LCR Chinook salmon would range from 0.02 to 0.1 percent of estimated species abundance—depending on life stage. Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. The potential mortality for of one adult natural origin LCR Chinook salmon would result from one sampling activity contemplated in this opinion. The additional eight mortalities already authorized were analyzed previously and found not to jeopardize the species.

California Coastal Chinook salmon

When combined with scientific research and monitoring permits already approved (Table 38), the potential mortality for CC Chinook salmon would range from 0.3 percent to 0.5 percent of estimated species abundance—depending on the life stage. The activities contemplated in this opinion represent only fractions of those already small numbers. In fact, 8 percent (3/35) of the adult CC Chinook salmon mortality and only 0.7 percent (28/3,962) of the juvenile CC Chinook salmon mortality, would result from activities contemplated in this opinion. Therefore, nearly all of the displayed total potential mortality has been previously analyzed and found not to jeopardize the species.

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

This would mean that the actual effect is likely to be much lower than the numbers stated in the table above.

Central 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 0.1 to 2.5 percent of estimated species abundance—depending on the origin and life stage (Table 38). The 2.5 percent potential mortality figure is for adult LHAC origin fish that have no take prohibitions because they are considered surplus to recovery needs, therefore, we do not expect the loss to have any genuine effect on the species' survival and recovery in the wild. The potential mortality for natural-origin CVSR Chinook salmon would range from 0.7 to 2.2 percent of estimated species abundance—depending on life stage. Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. The potential mortality for natural origin CVSR Chinook salmon would range from 19 percent (5/27) percent for adult salmon to 0.01 percent (89/16,921) 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. More than three quarters of the potential mortality for adults and nearly all of the total 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 tables 37 and 38 above. For naturally produced CVSR Chinook, our research tracking system reveals that for the past ten years, researchers ended up taking 11 percent of the adults and 9 percent of the juveniles they requested. The actual mortality was only 0.3 percent for adults and 4 percent for juveniles of what was requested. This would mean that the actual effect is likely to be similarly small 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 0.7 to 8 percent of estimated species abundance—depending on the origin and life stage (Table 38). The potential mortality for natural origin SRWR Chinook salmon would range from 2.6 to 8 percent of estimated species abundance. Thus the projected total lethal take for all research and monitoring activities represents a small portion of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. The potential mortality for natural origin SRWR Chinook salmon would range from 35 percent for adult salmon (6/17) to 1.4 percent (70/5,147) for juveniles. Therefore, the majority of adult and nearly all of the juvenile total potential mortality for natural origin SRWR Chinook salmon has been previously analyzed and found not to jeopardize the species. We do not expect the potential mortality of adult and juvenile LHAC origin fish contemplated in this opinion to have any genuine effect on the species' survival and recovery in the wild; these fish have no take prohibitions because they are considered surplus to recovery needs.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 3 percent of the naturally produced adult and 12 percent of the juveniles they requested, and the actual mortality was only 8 percent of the adults and 5 percent of the juveniles requested. This would mean that the actual effect is likely to be similarly small fractions of 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 11.3 percent of estimated species abundance—depending on the origin and life stage (Table 38). The 11.3 percent potential mortality figure is for adult LHIA origin fish. The potential mortality for natural origin CCC coho salmon would range from 2.4 to 2.7 percent of estimated species abundance—depending on life stage. The activities contemplated in this opinion represent only portions of those small numbers. In fact, 35 percent (19/53) of the adult CCC coho salmon mortality, and 13 percent (493/3,728) of the juvenile CC Chinook salmon mortality, would result from activities contemplated in this opinion. For the hatchery component of this ESU, only 16 percent (6/37) of the adult mortality and three percent (50/1,467) of the juvenile mortality would result from activities contemplated in this opinion. Therefore, the majority of the total potential mortality for hatchery and natural origin components has been previously analyzed and found not to jeopardize the species.

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

Lastly, as noted in Section 2.5 the hatchery component of this ESU, which is expected to be most impacted by research actions, is not considered as critical to the survival and recovery of the ESU as the natural origin component. Therefore, take of the LHIA component of the population will have less of an impact on the productivity and genetic diversity of the ESU than equivalent take of natural origin adults would.

Southern Oregon/Northern California Coast coho salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for SONCC coho salmon would range from 0.02 to 0.3 percent of estimated species abundance—depending on the origin and life stage (Table 38). 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. Research activities contemplated in this opinion would not cause any mortality for natural origin SONCC coho salmon, and result in less than half (300/723) of the total authorized lethal take of the hatchery juvenile component (LHIA and LHAC) of this ESU. Therefore, nearly all of the potential mortality has been previously analyzed and found not to jeopardize the species. The total amount of take authorized for LHIA juvenile SONCC coho salmon, which includes research activities contemplated in this opinion, would at most still comprise only 0.12 percent (681/575,000) of the juvenile LHIA component of this ESU.

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

Northern California steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for NC steelhead would range from 0.2 to 0.5 percent of estimated species abundance—depending on the life stage (Table 38). Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. In fact, zero percent (0/18) of the adult natural origin NC steelhead mortality (no adult take proposed), and 0.1 percent (6/4,108) of the juvenile natural origin NC steelhead mortality, would result from activities contemplated in this opinion. Therefore, a nearly all of the displayed total potential mortality has been previously analyzed and found not to jeopardize the species.

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

California Central Valley steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for CCV steelhead would range from 0.1 to 5.6 percent of estimated species abundance—depending on the origin and life stage (Table 38). However, the activities contemplated in this opinion represent only fractions of the potential mortality analyzed. In fact, 11 percent (10/94) of the adult natural origin CCV steelhead mortality, and 1.6 percent (32/2,035) 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. We do not expect the potential mortality of adult and juvenile LHAC origin fish contemplated in this opinion to have any genuine effect on the species' survival and recovery in the wild; these fish have no take prohibitions because they are considered surplus to recovery needs.

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

Central California Coast steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for CCC steelhead would range from 0.05 to 2.3 percent of estimated species abundance—depending on the life stage (Table 38). The activities contemplated in this opinion represent only fractions of the potential mortality rates. In fact, 36 percent (18/50) of the adult natural origin CCC steelhead mortality, and 14 percent (775/5,397) of the juvenile natural origin CCC steelhead mortality, would result from activities contemplated in this opinion. No new take of the hatchery component of this ESU is proposed in research activities considered in this opinion. Therefore, the majority of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in

Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that for the past ten years, researchers ended up taking 3 percent of the adult and 13 percent of the juvenile CCC steelhead they requested and the actual mortality was only 1 percent of requested for adults and only 3 percent of the requested for juveniles. This would mean that the actual effect is likely to be similarly small 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 0.9 to 1.6 percent of estimated species abundance—depending on the age class (Table 38). 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 0.2 percent (3/1,245) of the juvenile natural origin S-CCC steelhead 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 ten years, researchers ended up taking 24 percent of the adult and nine percent of the juvenile S-CCC steelhead they requested and the actual mortality was zero percent of requested for adults and only four percent of the requested for juveniles. This would mean that the actual effect is likely to be similarly small fractions of the numbers stated in the table above.

Summation for Salmonids

One further thing to note for the all the species above: where impacts discussed are ascribed to the natural component of each listed unit, in actuality the effects are in all cases very likely to be smaller than the displayed percentages. The reason for this is that when in doubt—in those instances where a non-clipped (LHIA) hatchery fish cannot be differentiated from a natural fish—we ask that researchers err to the side of caution and treat all fish with intact adipose fins as if they were natural fish. Therefore, take reported as occurring for natural origin fish is actually distributed over the natural and LHIA components of the ESU or DPS. As discussed previously, the loss of hatchery origin fish is expected to have less of an impact on productivity and genetic diversity of the population than equivalent mortality of natural origin fish.

Moving from the specific to the general, it is necessary to note that for *all* the species the actual take amounts would almost certainly be a great deal smaller than what has been (or may be) authorized—particularly for juvenile fish. There are three reasons for this. First, we develop conservative estimates of juvenile abundance (described in subsection 2.2 above). Second, to account for potential accidental deaths, the researchers request more take and more mortalities than they estimate would actually occur in a given year. To illustrate this, our research tracking system reveals that on average researchers end up taking about 37 percent of the fish they estimate when applying for a permit and killing about 15 percent of the numbers they estimate. In the current context, this would mean that for the juvenile take in Table 38, above, that *actual* mortality levels would probably be nearly an order of magnitude smaller than those displayed. Third, some of the fish that may be affected would be in the smolt stage, but others definitely would not be. These latter would simply be described as "juveniles," which means they may actually be subyearlings, parr, or even fry. Thus, fish grouped into the juvenile life stage represent the progeny of multiple spawning years—a much greater number of individuals (perhaps as much as an order of magnitude greater) than is represented by the smolt stage.

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

Similarly, the take contemplated in this opinion for the adult components would unlikely have significant effect on the species viability. Even if the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small. Because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population).

Moreover, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery. Many of the research and monitoring programs contemplated in this opinion are intended to address the paucity of data, which, for many species and populations, limits our ability to accurately estimate viability and effectively plan, execute, and assess recovery efforts. These data will also be used to ensure that restoration projects and other recovery actions are working as anticipated, and providing the intended benefit to the target species. Therefore, the overall benefit to the survival and recovery of the salmonid species considered in this opinion is likely to outweigh the small reductions in abundance and productivity caused by research take.

Southern Distinct Population Segment Green Sturgeon

When combined with scientific research and monitoring permits already approved, the potential mortality for adult sDPS green sturgeon would constitute 0.1 percent of the estimated spawning abundance (Table 38). Further as noted in Section 2.2 above, the spawning run estimate for sDPS green sturgeon is conservative in that it does not include fish from the entire known spawning range of the DPS, and does not include the members of the population, which do not return to spawn each year. Further, some of the sampling occurs in Bay-Delta locations that are outside of the Sacramento River, where the spawning run size population estimate included for this analysis is derived, so the mortality would possibly be absorbed by a larger segment of the population then just the annual Sacramento River spawning run. In addition, a large percentage of the take that is listed in previously authorized permits as adult green sturgeon take, which occurs in the San Francisco Estuary, may be more aptly categorized as sub-adult or juvenile take.

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 nine percent of the sDPS green sturgeon they requested and the actual mortality was only eight percent of what was 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.

Critical Habitat

As previously discussed, 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 earlier, 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 very minor effect on the species' survival and recovery. In all cases, even the worst possible effect on abundance is expected to be minor compared to overall population abundance, 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 the Pacific Northwest have provided resource managers with a wealth of important and useful information regarding anadromous fish populations. For example, juvenile fish trapping efforts have enabled managers to produce population inventories, PIT-tagging efforts have increased our knowledge of anadromous fish abundance, migration timing, and survival, and fish passage studies have enhanced our understanding of how fish behave and survive when moving past dams and through reservoirs. 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 with respect to sustaining anadromous salmonid populations, mitigating adverse impacts on endangered and threatened salmon and steelhead, and implementing 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. Though 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. As a result, 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 primary 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 minor reductions in juvenile and adult abundance and productivity. And because these reductions are so slight, the actions—even in combination—would have no appreciable effect 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 actions are not likely to jeopardize the continued existences of LCR, CCC, CVSR and SRWR Chinook salmon; CCC and SONCC coho salmon; NC, CCC, CCV, and SCCC steelhead or sDPS green sturgeon, or destroy or adversely modify their designated critical habitats.

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 ITS.

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 their actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot be considered "incidental" under the definition given 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 (2.5). 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 reinitiation clause just below.

2.10 Reinitiation of Consultation

This concludes formal consultation for "Consultation on the Issuance of Thirteen ESA Section 10(a)(1)(A) Scientific Research Permits in California affecting Salmon, Steelhead, and Green Sturgeon in the West Coast Region."

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 ITS 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 on 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.

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 (2.5) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) and/or (3) will have been met.

2.11 "Not Likely to Adversely Affect" Determination

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

Southern Resident Killer Whales Determination

The Southern Resident killer whale DPS was listed as endangered on February 16, 2006 (70 FR 69903) and a recovery plan was completed in 2008 (NMFS 2008). A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016b). Because NMFS determined the action is not likely to adversely affect SKRWs, this document does not provide detailed discussion of environmental baseline or cumulative effects for the SRKW portion of the action area.

Several factors identified in the final recovery plan for Southern Resident killer whales may be limiting recovery including quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008).

Southern Resident killer whales consist of three pods (J, K, and L) and inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008; Hanson et al. 2013; Carretta et al. 2017). During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford 2000; Krahn et al. 2002; Hauser et al. 2007; Hanson and Emmons 2010). By late fall, all three pods are seen less frequently in inland waters. In recent years, several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010; Hanson et al. 2013, NWFSC unpubl. data). Satellite-linked tag deployments have also provided more data on the Southern Resident killer whale movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months.

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling from May to September indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Prey remains and fecal samples collected in inland waters during October through December indicate Chinook salmon and chum salmon are primarily contributors of the whale's diet (NWFSC unpubl. data).

Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2007) and collection of prey and fecal samples have also occurred in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data).

At the time of the last status review in 2016 there were 83 Southern Resident killer whales left in the population (NMFS 2016f). Recent estimates based on a July 2019 survey indicate Southern Residents now total approximately 73 individuals (22 in J pod, 17 in K pod, and 34 in L pod, CWR 2019). The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses for Southern Resident killer whales and a science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates, however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate (Lacy et al. 2017).

The proposed actions may affect Southern Residents indirectly by reducing availability of their preferred prey, Chinook salmon. This analysis focuses on effects to Chinook salmon availability in the ocean because the best available information indicates that salmon are the preferred prey of Southern Resident killer whales year round, including in coastal waters, and that Chinook salmon are the preferred salmon prey species. To assess the indirect effects of the proposed action on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales. We also considered the importance of the affected Chinook salmon ESUs compared to other Chinook salmon runs in Southern Resident diet composition, and the influence of hatchery mitigation programs. As described in the effects analysis for salmonids, approximately 282 juvenile and 22 adult Chinook salmon may be killed during the course of the research. As the previous effects analysis illustrated, these losses—even in total—are expected to have only very small effects on salmonid abundance and productivity and no appreciable effect on diversity or distribution for Chinook salmon ESUs. The affected Chinook salmon species are:

- Lower Columbia River (LCR)
- Central Valley spring-run (CVSR)
- Sacramento River winter-run (SRWR)
- California Coastal (CC)

Of these, SRWR and CC Chinook salmon are not considered priority prey stocks for Southern Resident killer whales. These two Chinook salmon ESUs have a low potential for spatio-temporal overlap with the whales, would not be available as prey during times of reduced whale body condition, and have not been observed in the whale diet based on opportunistic sampling (NMFS and WDFW 2018). Therefore, we only further consider LCR and CVSR Chinook salmon in this analysis.

The fact that the research would kill LCR and CVSR Chinook salmon could affect prey availability to the whales in future years throughout their range. For the adult take, the 10 fish that may be killed from these ESUs would only be taken by research after they return to shallower bays and estuaries, and are unlikely to be available as prey to the whales that typically feed in offshore areas of the California coast. This impact would therefore likely have a minimal, if any, affect on prey availability for Southern Resident killer whales.

For the juveniles, the most recent ten-year average smolt-to-adult ratio (SAR) from PIT-tagged Chinook salmon returns is from the Snake River, and indicates that SARs are less than 1% (BPA 2018). If one percent of the 139 juvenile CVSR Chinook salmon that may be killed by the proposed research activities (no juvenile LCR Chinook salmon are proposed to be killed) were otherwise to survive to adulthood, this would translate to the effective loss of 1-2 adult Chinook salmon. When added to the 10 adults that may be killed during the course of the research in bays and estuaries, that would mean a possible total effect of 12 dead adults (or their equivalent). Given that the SRKW population must catch a minimum of 1,400 salmon daily to sustain their needs (CWR 2018), this means that the research contemplated in this opinion could kill, in its entirety, less than one percent of *one day's* worth of the fish that the SRKWs need to survive. Moreover, that figure would only hold if the SRKWs could somehow intercept *all* the fish that might reach maturity. Therefore, even the maximum effect of a loss of 0.9% of one day's worth of SRKW food could only occur under the most unlikely circumstances.

In addition, as described in Section 2.5 the estimated Chinook salmon mortality is likely to be much smaller than stated. First, the mortality rate estimates for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer salmonids will be killed by the research than stated. In fact, as described in Section 2.5 according to our take tracking in the past researchers have only killed about 4% of the naturally-produced juvenile CVSR Chinook salmon they were permitted to kill (and even fewer adults). Thus, the actual reduction in prey available to the whales is probably closer to one fish rather than 12.

Even assuming the equivalent of 12 adults were killed, given the total quantity of prey available to SR killer whales throughout their range, this small reduction in prey caused by the research would have at most an insignificant effect on the whales' survival and recovery.

Similarly, the future loss of Chinook salmon could affect the prey PBF of designated critical habitat for killer whales. As described above, however, and considering the conservative estimate of 12 Chinook salmon adult equivalents that could be taken by the proposed actions and the total amount of prey available in critical habitat, the reduction would be so small that it would not affect the conservation value of the critical habitat in any meaningful or measurable way.

Given these circumstances, and the fact that we anticipate no direct interaction between any of the researchers and the SR killer whales, NMFS finds that potential adverse effects of the proposed research on Southern Residents are insignificant and determines that the proposed action may affect, but is not likely to adversely affect, SR killer whales or their critical habitat.

References:

Center for Whale Research (CWR) 2019. Southern Resident Killer Whale Population. https://www.whaleresearch.com/orca-population; accessed online September 5, 2019.

NMFS 2016f. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, West Coast Region, Seattle, WA. December 2016.

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 the EFH assessment provided by the NMFS and descriptions of EFH for Pacific Coast salmon (PFMC 2014) 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 km) offshore of Washington, Oregon, and California north of Point Conception. The EFH identified within the action areas are identified in the Pacific coast salmon fishery management plan (PFMC 2014). 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).

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, groundfish, and coastal pelagic species, depend; the research is therefore not likely to affect EFH. 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 adverse effects upon EFH are expected; therefore, no EFH 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 NMFS 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 NMFS' 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 opinion are the applicants and funding/action agencies listed on the first page. This opinion will be posted with the NOAA Institutional Repository (https://repository.library.noaa.gov/). The format and naming adheres to conventional standards for style.

This ESA section 7 consultation on the issuance of the ESA section 10(a)(1)(A) research permit concluded that the actions will not jeopardize the continued existence of any species. Therefore, the funding/action agencies may carry out the research actions and NMFS may permit them. Pursuant to the MSA, NMFS determined that no conservation recommendations were needed to conserve EFH.

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, and 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 contain more background on information sources and quality.

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

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

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